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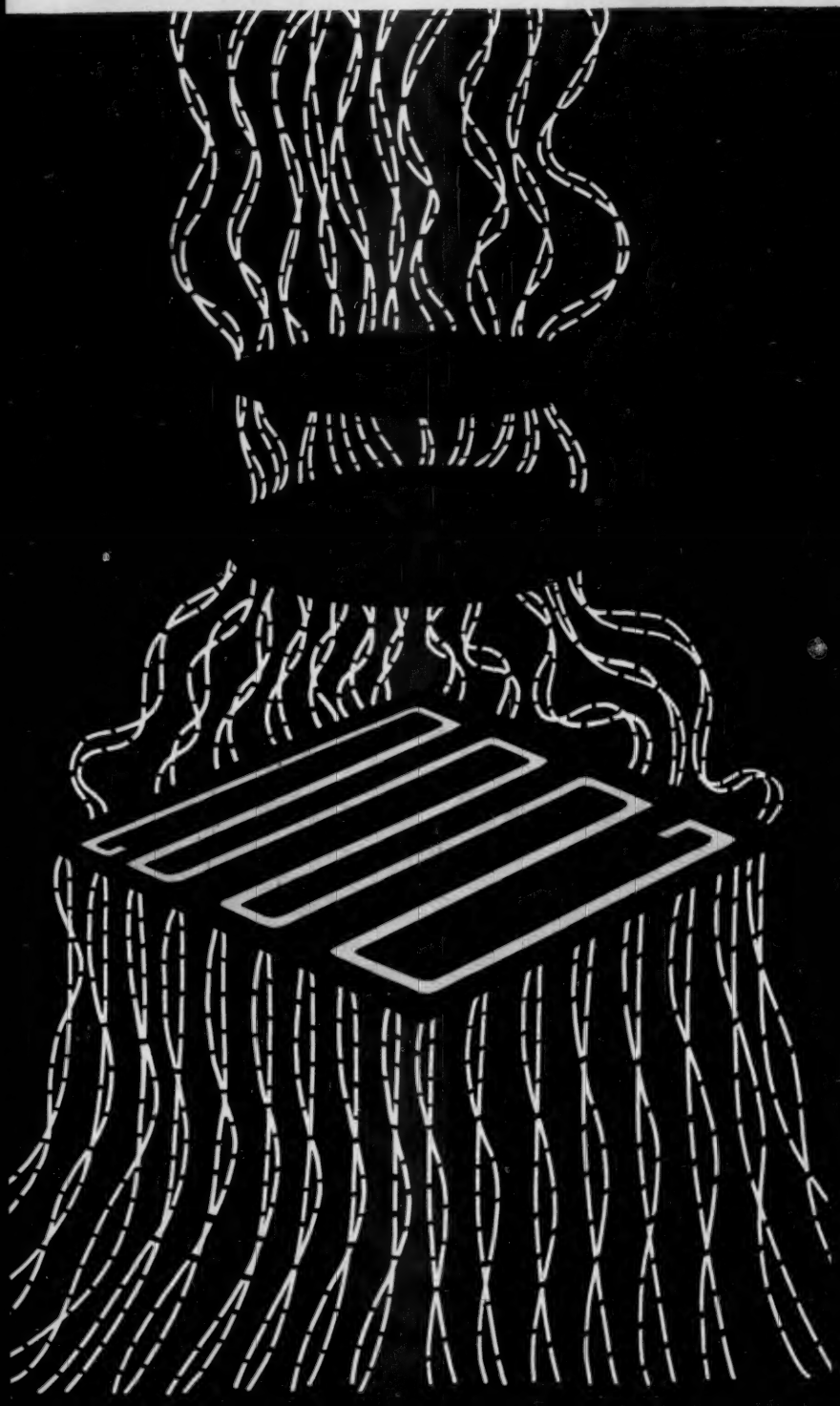

Composite of Air-Cooled Heat Exchanger DESIGN TRENDS

p. 91

Statistics: a tool for the estimator, p. 97

New data on entrainment from perforated trays, p. 101

Rate yourself as an executive, p. 131

Photomicrograph of an air bubble entrapped in a lacquer film on mahogany panel.

Portrait of a problem . . .

Problems abound at every step in surface coating formulation and application. This portrait of a tiny blister represents only one of many challenges Shell Chemical technicians encounter in their continuing program of practical and theoretical research.

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Chemical Engineering

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

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Check Reader Service Postcard, p. 268.

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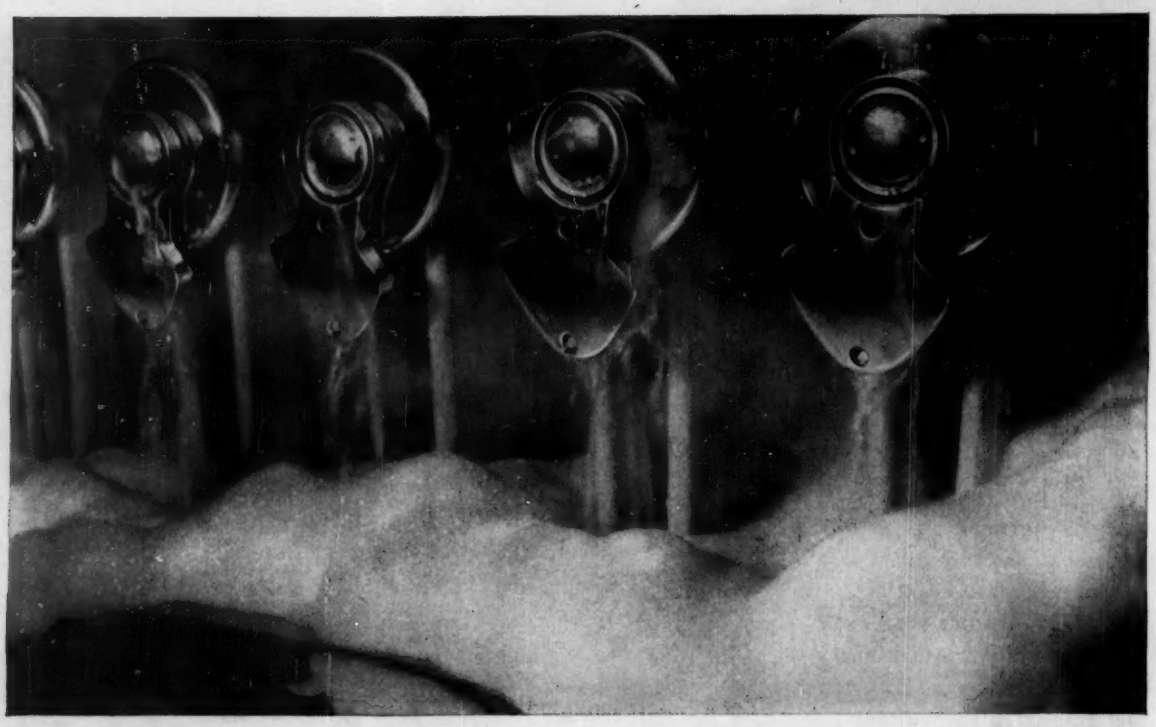

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highlights of this issue

DESIGN OF AIR-COOLED HEAT EXCHANGERS

Most articles on design of heat exchangers concern only the heat-transfer characteristics of the exchanger. This one (p. 91) points out the mechanical design factors that affect selection and operation of air-cooled exchangers. It's written by Frank Rubin of Downingtown Iron Works, whose name is well known to *CE* readers as author of several previous articles in the field of heat exchange.

NEW PROCESS AUTOMATES SALT REFINING

It's been a long time, but we finally have the story (p. 49) on International Salt's first full-scale use of its new salt refining technique. We've been on the track of this development ever since March 1952, when we first published details of the pilot-plant work. The new process capitalizes on the inverse solubility curve of calcium sulfate, avoiding the need for chemical treatment in production of high-purity salt directly from low-grade rock salt.

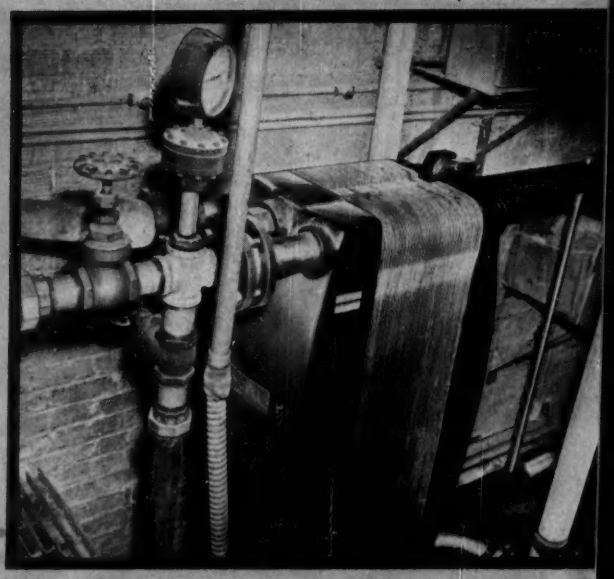
SCORE YOUR EXECUTIVE ATTRIBUTES

Rate yourself—or your boss—against this checklist of essential attributes of managers (p. 131), prepared by consultant Richard S. Schultz. If you're looking ahead to a career in management, Dr. Schultz's article will suggest ways in which you can prepare yourself for executive responsibilities.

NEW DATA ON ENTRAINMENT FROM PERFORATED TRAYS

What's the optimum tray spacing for a perforated-tray distillation or absorption tower? Key factor to consider is degree of entrainment, yet previously available entrainment data don't adequately cover the close spacings dictated by today's process and economic trends. Kellogg engineers Friend, Lemieux and Schreiner present a wealth of information in their comprehensive article (p. 101).

De Laval tackles process problems



...economically!

New separations made possible by new pressurized centrifuge

Example #1 – highly volatile, inflammable liquid is to be centrifugally separated from water

Example #2 – a foamy, viscous product is to be clarified

Example #3 – a gummy product is to be separated in the purest state possible from the reaction mixture

All of these would be routine problems for the new De Laval SRG-214 Hermetic centrifuge. Capable of operating at pressures up to 125 psi (and higher where necessary), it will process flammable liquids, keep air strictly out of a clarification or separation operation. Resinous, rubbery or waxy reaction products can be separated in their *fluid* state without exposure to air or loss of volatile fluids. Volatile materials can be processed at temperatures otherwise impractical because of vapor problems.

The SRG-214 is a disc-type constant-efficiency centrifuge and is available in corrosion-resistant stainless steel design. Special inlet and outlet seals permit its use under pressure. As a separator, the SRG-214 gives highly efficient separation of immiscible liquids. Ample bowl space for sediment accumulation permits its use as a clarifier as well. Capacities go to 5,000 gals. per hr.

Don't guess. Let us pre-test your separation problem in our own full-scale pilot plant—and provide useful operating data. Write us.

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CENTRIFUGES
PLATE HEAT EXCHANGERS
VIBRATING SCREENS
COMPLETE PROCESSES

Water was scarce . . .
and the tubes were clogging up something awful!

The material was a 13,500 lb/hr shellac-soda ash solution which required rapid cooling from 200° to 70° after de-waxing. A shell-and-tube was bogging down the whole operation with frequent clogging. Lack of water also focused attention on cooling efficiency.

A single section De Laval P-12 Plate Heat Exchanger did the job using less of the 60° cooling water than product stream! The 10° differential indicates the transfer efficiency. Cleaning became a quick and easy operation because the stainless steel plates opened in a moment. The illustration shows how compact this De Laval P-12 Plate Heat Exchanger is.

In another application, the heating of a latex solution caused coagulation that made the use of tube and shell type units impractical. Here the stream was over 250,000 lbs/hr and a two-section De Laval P-15 Plate Heat Exchanger handled the heating requirements easily and offered a practical and inexpensive solution to the clean-up problem.

De Laval offers the widest range of plate heat exchangers available. Our experience can help you.

THE HEAT EXCHANGER'S HEAT EXCHANGER

"Master your craft and you become known, for example, as 'the ballplayer's ballplayer' or 'the comedian's comedian.' There's a rumor (we're spreading it!) that De Laval Plate Heat Exchangers are the . . . you guessed it! Because of their remarkable heat transfer efficiency, extreme compactness and ease of operation and maintenance, our plate heat exchangers are judged to be in a top rank by themselves. Two typical installations where they solved difficult problems are discussed here."

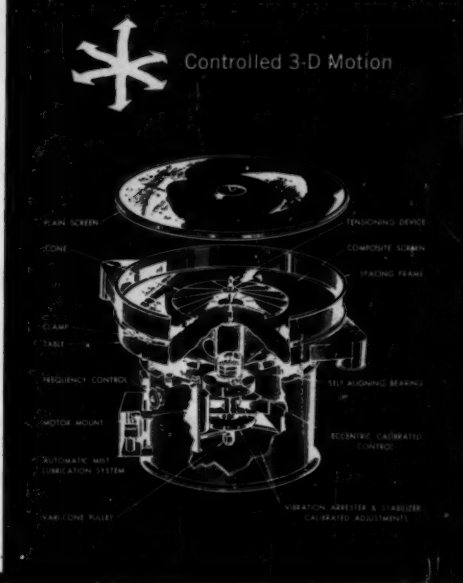
Fred Wheelwright, Industrial Sales Manager

This vibrating screen shook up a pound of inquiries

Anyone using a screen separator is looking for a better one—it seems. Anyway, after the recent Chemical Show, we had on hand almost a pound of inquiry cards voluntarily filled out by bonafide prospects for our Syncro-Matic Screen Classifiers. It was a popular attraction, indeed.

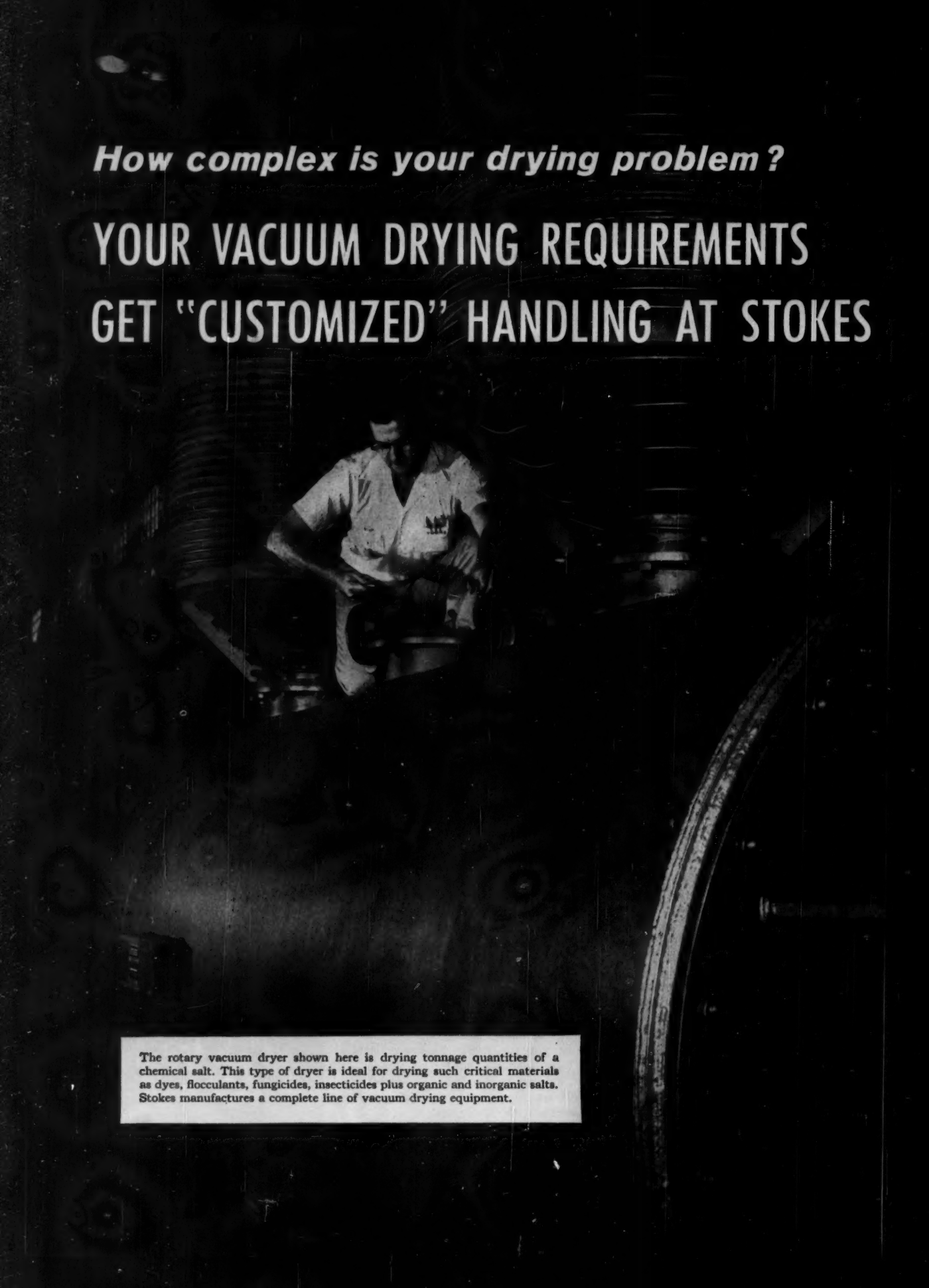
Lookers became prospects when they found that our Syncro-Matic offered a full range of *three-dimensional* controlled motion ranging from gentle classification to turbulent sifting. The frequency is controlled by turning a knob, and the eccentricity control is calibrated for accurate pre-setting. Direct mechanical linkage *assures* a constant classifying action that, unlike gyratory types, does not dampen with heavy loading. Available screens, plain or composite, run the full range of commercial meshes and materials, and you can operate with one, two, or three decks. The base is practically vibrationless and operation is exceptionally quiet.

Soft foodstuffs, abrasive crystals, dry granules, liquids or slurries—all can be handled with excellent through-put and classifying efficiency. Write for details.



How complex is your drying problem?

YOUR VACUUM DRYING REQUIREMENTS GET "CUSTOMIZED" HANDLING AT STOKES



The rotary vacuum dryer shown here is drying tonnage quantities of a chemical salt. This type of dryer is ideal for drying such critical materials as dyes, flocculants, fungicides, insecticides plus organic and inorganic salts. Stokes manufactures a complete line of vacuum drying equipment.

Conical Vacuum Dryer shown below in Stokes laboratory is being used for a variety of tests on customer products.

PROCESSING tonnage quantities of materials in an inadequate vacuum dryer can be time consuming and costly. That's why Stokes experienced vacuum engineers study each drying requirement individually . . . then design the drying system to meet your specific needs. Drying systems in capacities from a few pounds to several tons are available . . . along with application engineering, laboratory service and pilot plant operations. Stokes puts its 50 years of vacuum processing experience to work on every drying problem . . . bringing you both money-saving and quality results. What's more, Stokes manufactures all its own pumps and accessories to assure you one-manufacturer responsibility in addition to unparalleled vacuum know-how.

Stokes will thoroughly explore your production problems . . . make recommendations on the basis of a practical knowledge of process operations . . . and confirm the recommended equipment by actual pilot plant production in the Stokes laboratory, if necessary.

Our representative in your area will initiate Stokes action to assure the best answer to your drying problem. Why not call him soon? Or if you prefer, write for new summary booklet on drying applications.

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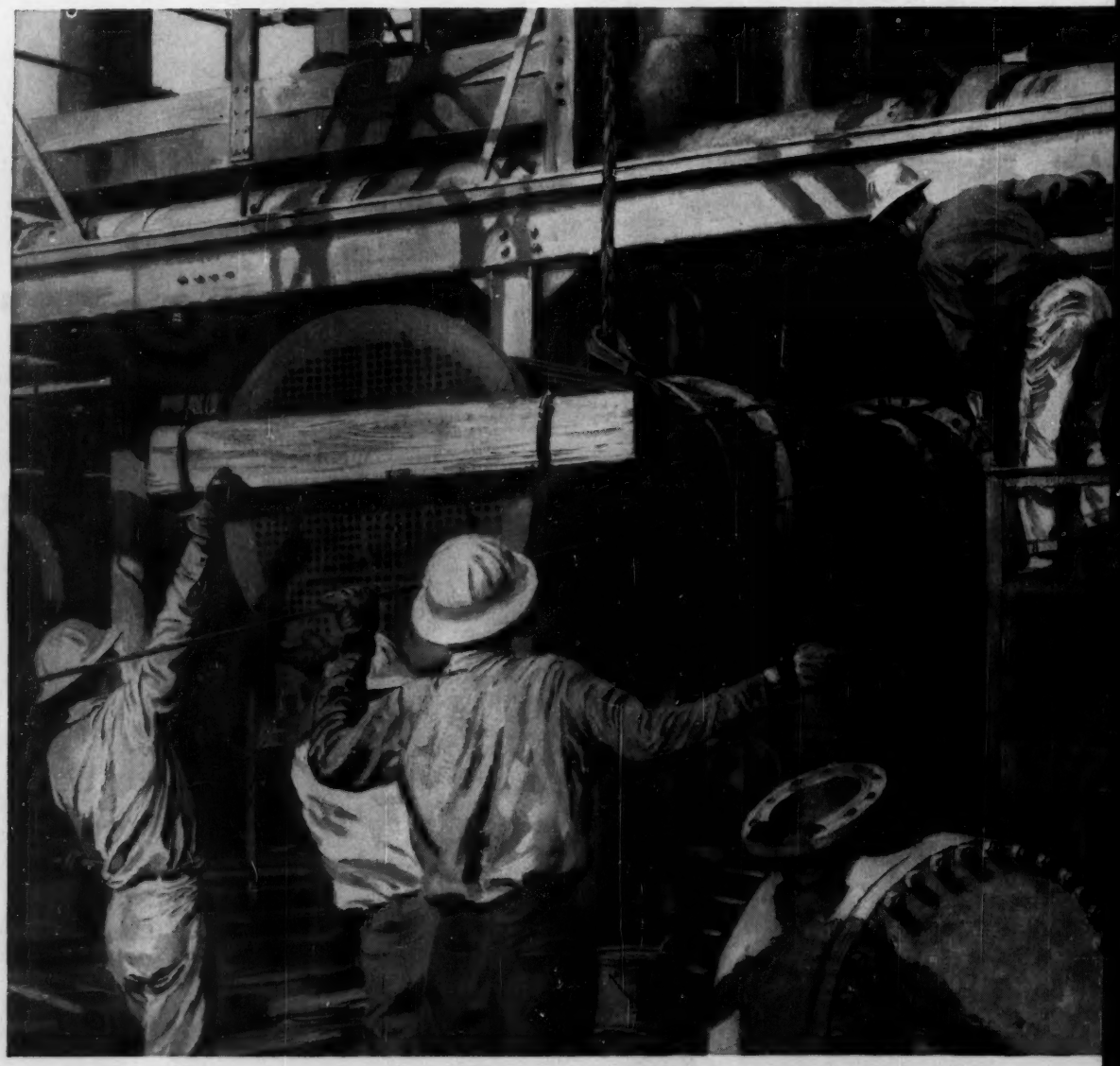

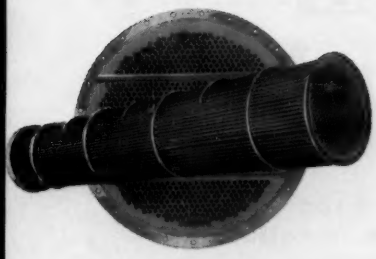

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Factory-aligned components assure low-cost installation, smooth performance

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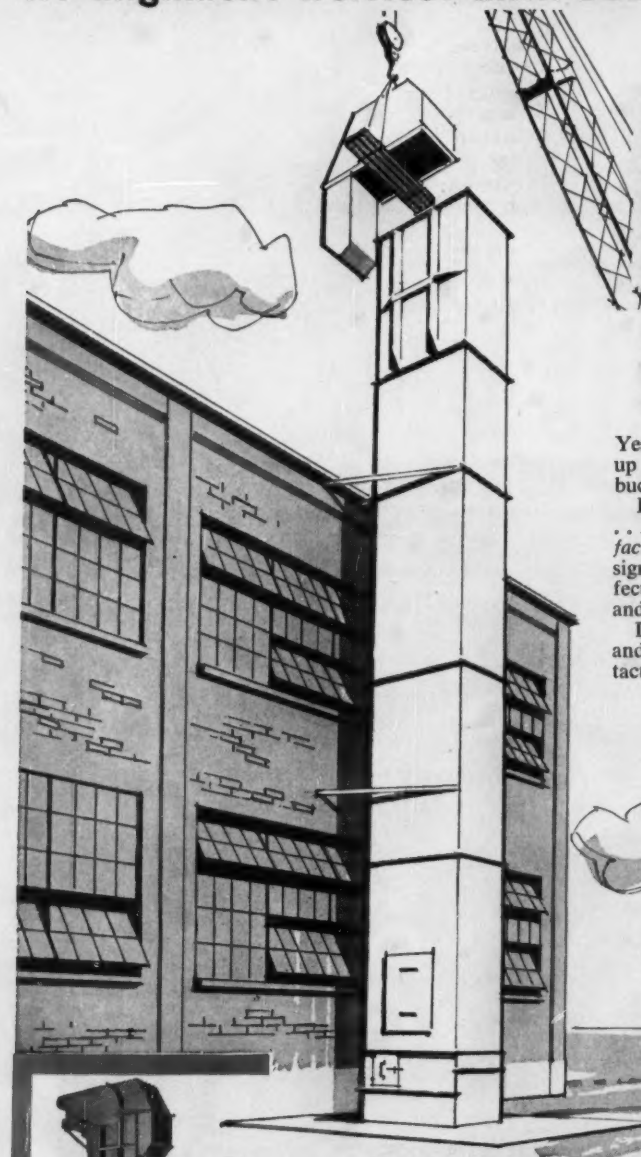
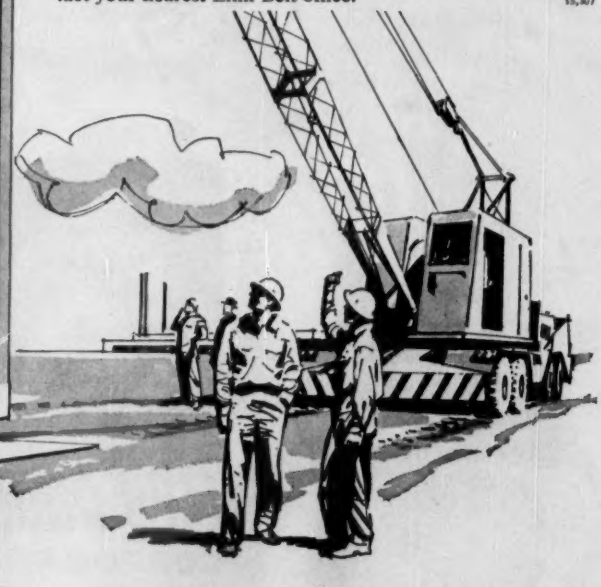
Link-Belt manufactures *all* bucket elevator components . . . eliminates installation and operational problems in the *factory*, not in the field! All components are carefully designed and manufactured. Casings are jig-welded for perfect, ready alignment. Result: Unnecessary erection costs and difficulties are avoided, long-lasting efficiency assured.

Link-Belt will gladly erect your elevator (large or small) and accept full installation responsibility. For details, contact your nearest Link-Belt office. 15,307





CENTRIFUGAL DISCHARGE bucket elevators are designed to handle free-flowing, fine and loose materials with small to medium lumps. Type 14 (shown) is built for high capacities.

Link-Belt's complete bucket elevator line includes 14 types in 4 basic designs . . . centrifugal, positive, continuous and internal discharge. Also a wide variety of buckets . . . steel, malleable iron, Promal or alloy metals.

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- Availability of drums with and without rolling hoops.
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Insert shows detail of Hackney seamless chime construction

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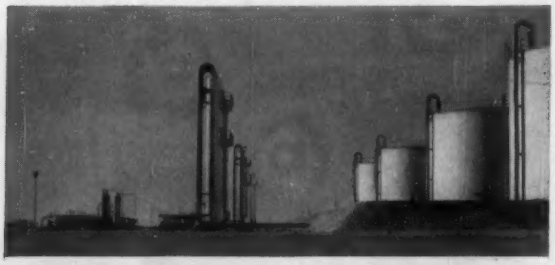
NEW PROCESSING PLANT AT HASSI-MESSAOUD STABILIZES 150,000 B/SD OF LIGHT CRUDE

The S. N. REPAL permanent field processing plant at Hassi-Messaoud, Algeria, is now operating at its capacity of 150,000 barrels per stream day of stabilized crude oil. The installation gathers, degasses, stores and transports a very light crude (0.8 sp. gr.) produced at the four-year-old Hassi-Messaoud field and destined for the Haoud El Hamra-Bougie pipeline to the Mediterranean. It was built by Societe Francaise des Techniques Lummus in this remote location, under extreme climatic conditions, in less than nine months from the time materials began to arrive at the site—and was completed ahead of schedule.

General view of the Hassi-Messaoud plant, showing vertical, third stage separators (center), part of horizontal separators, and four intermediate storage tanks.



Rear view of control house with its specially-designed roof for Saharan climatic conditions.

In May, 1958, Societe Francaise des Techniques Lummus was assigned the task of planning, engineering and constructing the plant, the primary purpose of which is to remove the very large quantities of natural gas associated with the Hassi-Messaoud crude (gas: oil ratio by volume is about 200:1). A temporary installation handling limited crude capacity existed at the site when the Lummus company was called in.

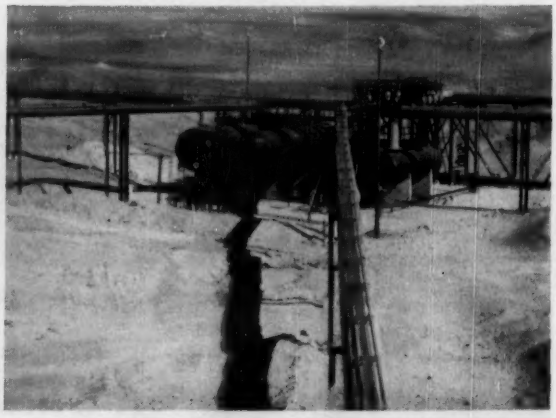
By September, 1958, plans were completed and purchasing began. Almost all the materials were bought in France or Algeria. However, electronic control apparatus was obtained in the United States. Over 4,000 tons of material were transported across the Mediterranean Sea, the Atlas Mountains, and the desert to arrive at a rocky plateau rising about 100 feet above the old dry valley of Oued Irara.

In addition to transportation difficulties, Societe Francaise des Techniques Lummus had these handicaps to overcome during construction proper, which got underway in January, 1959: a water table lying 150 feet deep, which posed problems in electrical grounding of equipment; conducting the major part of the work during the hottest months, with temperatures ranging from 104-130°F.; violent sand and dust storms, characteristic of the area.

In spite of the problems, on September 24, 1959 —ahead of schedule—the gas separators were put into operation and the flares lit. The first shipments through a 16-inch pipeline to Haoud El Hamra Terminal, 19 miles away, began shortly thereafter.

SFTL is one of the seven International Groups of Lummus companies which circle the globe to serve the process industries wherever plant design, engineering and construction are needed.

The condensate drums and control station with the high and low pressure flares.



Two skids hold complete nitrous oxide plant ready to move to location in "flying boxcar."

Portable Nitrous Oxide Generator Being Constructed for U. S. Army Engineers

Design, construction and testing of a portable nitrous oxide generator for the U.S. Army Corps of Engineers is being carried out by The Lummus Company at its Engineering Development Center, Newark, N. J.

The plant will afford a field supply of 40 lb. per hr. of liquid anesthesia for use under combat conditions, at a cost of about $250,000 per generator. The process, specified by the Army, is conventional decomposition of ammonium nitrate by heat. Ammonium nitrate can be shipped in bags, eliminating the return of empty anesthesia cylinders which presently causes problems.

Dimensions of the unit were dictated by the size of the rear door of a "flying boxcar". As designed, the plant is mounted on two skids, eight feet square by 20 feet long. It has shock and thrust resistance for portability by plane, train or truck. It is simple enough for operation by soldiers getting instruction from a manual.

The nitrous oxide product meets USP purity requirements.

The equipment in the unit includes:

On the first skid

Ammonium nitrate melting pots of aluminum.

Decomposition vessels of aluminum.

Caustic, sulfuric acid and steel wool scrubbers made of glass-fiber-reinforced polyester resin. Packings for the caustic and acid scrubbers are polyethylene Tellerettes.

On the second skid

Compressor of a type that compresses gas by flexing a diaphragm with hydraulic fluid.

Hot KOH absorber.

Desiccator.

Liquefier – a 1¼-ton fluorinated hydrocarbon refrigeration unit.

Stripper.

Bridging the two skids

A plastic gas-surge bag of 300 cu. ft. capacity which weighs only 30 pounds and folds up into a small bundle for storage. It consists of an inner envelope of vinyl plastic sheeting and an outer casing of vinyl-impregnated nylon fabric. It was specially designed for this portable plant.

Because parameters set by the Army pose many problems in selection of materials of construction, selection and positioning of equipment and instrumentation, Lummus' Engineering Development Center will provide the Army with an R&D prototype unit which may save them a great deal of expense and inconvenience.

Over a half-century of Process-Industry experience

Here is just a partial list of chemicals for which Lummus has designed, engineered or constructed plants:

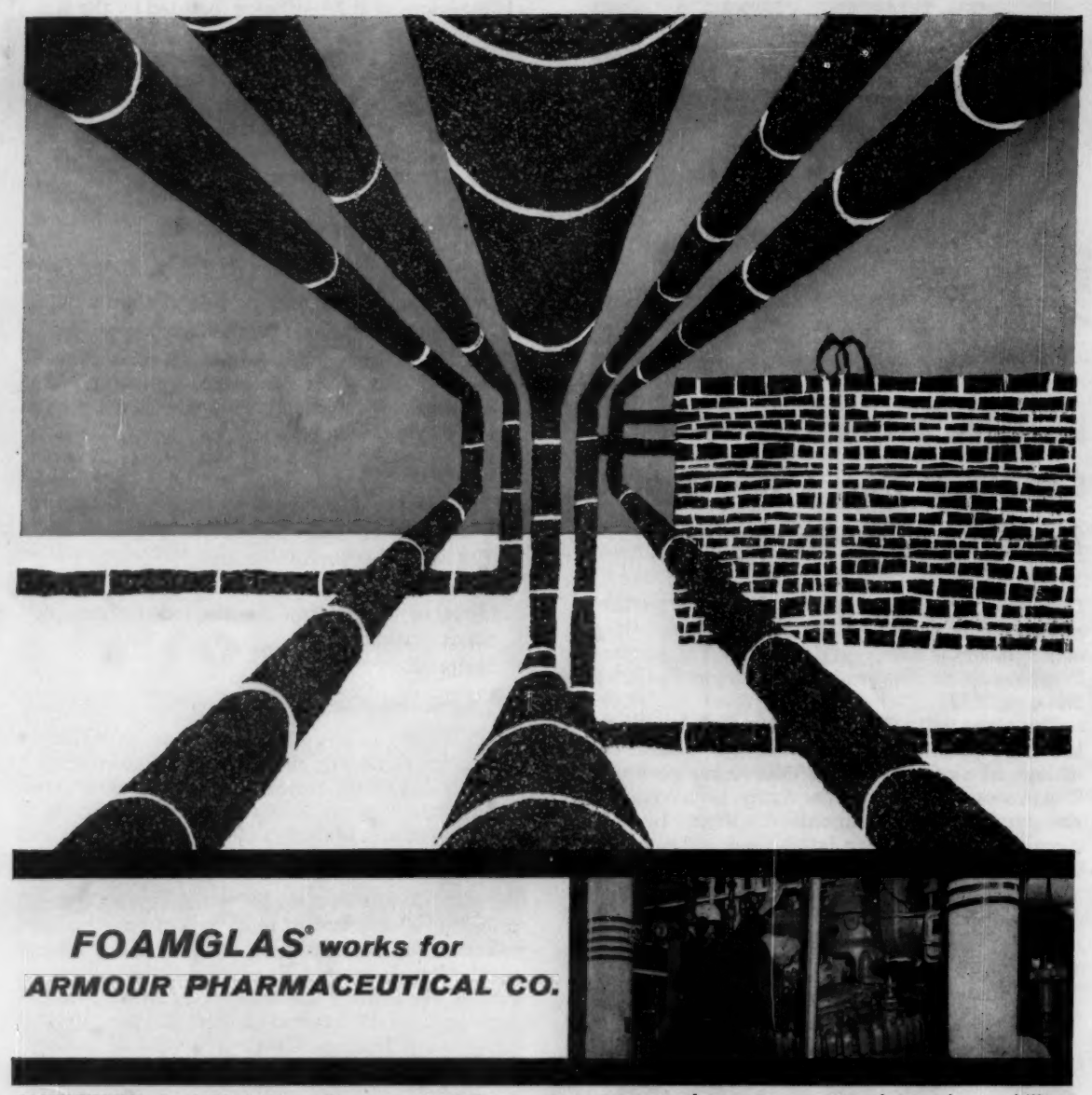
Acetone	Dichlorethane	Nitric acid
Acrolein	Dichlorobenzene	Phenol
Allethrin	Di-isobutyl alcohol	Phthalic anhydride
Ammonia	Ethylbenzene	Polyvinyl alcohol
Ammonium nitrate	Ethyl chloride	Polyvinyl pyrrolidone
Ammonium sulfate	Ethylene	Propargyl alcohol
Benzol	Ethylene glycol	Propylene
Beryllium metal	Ethylene oxide	Pyrrolidone
Bisphenol	Epon® resin	Styrene
Butadiene	Formaldehyde	Sulfuric acid
Butanediol	Heavy water	Surfactants
Butynediol	Hydrogen	Tetramer
Butyrolactone	Hydrogen sulfide	Trichlorethylene
Carbon black	Isopropyl alcohol	Trichlorobenzene
Caustic soda	Lamp black	Toluene
Chlorobenzene	Magnesium sulfate	Uranium oxide
Cumene	Mercuric nitrate	Vinyl acetate
Di-ammonium phosphate	Naphthalene	Vinyl pyrrolidone

Discuss your next chemical or petrochemical project with a Lummus representative.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y.; Houston, Washington, D. C.; Montreal, London, Paris, The Hague, Madrid. **Engineering Development Center:** Newark, N. J.

FMC selects Lummus as principal sub-contractor on new Army Chemical Corps Contract

A new Army contract for a Chemical Corps production facility near Newport, Indiana, in excess of $13,000,000, has been awarded to the Food Machinery & Chemical Corporation. The contract calls for the design, construction and test operation of a plant to produce classified material. The Lummus Company has been selected as principal sub-contractor to design, construct and assist in test operation. Food Machinery & Chemical Corporation have the responsibility for operating this government-owned contractor-operated facility for some period to follow.



FOAMGLAS® works for ARMOUR PHARMACEUTICAL CO.

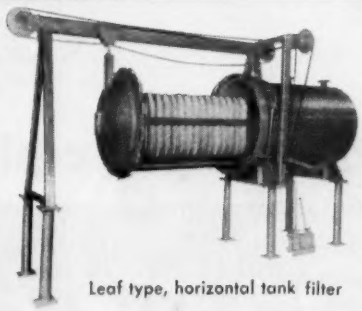
EVIDENCE: In 1953, Armour Pharmaceutical Company, a division of Armour and Company, constructed a modern pharmaceutical lab at Kankakee, Ill. Insulation needs were varied and demanding. Armour found one material—FOAMGLAS insulation—that worked in a variety of applications: in special cold rooms, in piping, tanks and vessels. The reason? This unique combination of benefits: constant insulating value; high compressive strength; incombustibility; vapor-proof; and ease of cutting and shaping.

Outdoors, FOAMGLAS insulation works to: protect ammonia lines against condensation, corrosion, and harsh temperature changes . . . prevent heat gain on chilling tanks and piping. Indoors, FOAMGLAS insulation forms a complete envelope—floors, walls and ceilings—in cold storage rooms where various temperatures from —20° on up must be maintained . . . holds chilled water piping at a constant 42°. And all this without maintenance problems.

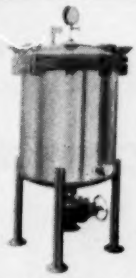
See how FOAMGLAS can work on your insulation problems. Write for a free copy of our Insulation Catalog and the Armour Fact Sheet. Pittsburgh Corning Corp., Dept. H-101, One Gateway Center, Pittsburgh 22, Pennsylvania. In Canada: 3333 Cavendish Boulevard, Montreal, Quebec.

Pittsburgh Corning makes available a complete line of accessory materials for use with FOAMGLAS insulation. Write for Data Sheets.

PITTSBURGH PC CORNING



Leaf type, horizontal tank filter



Leaf type, vertical tank filter

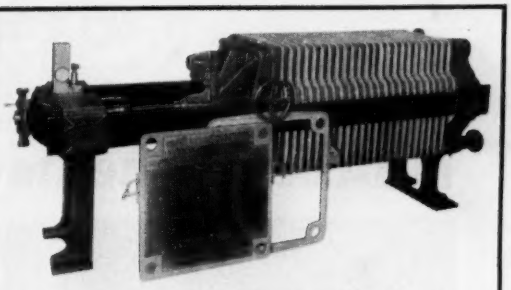
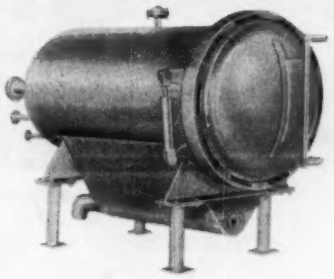
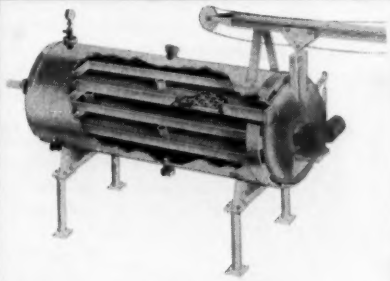


Plate and frame filter press

It's true—we build many types of filters



Rotary leaf type positive sluicing filter



Horizontal tray filter

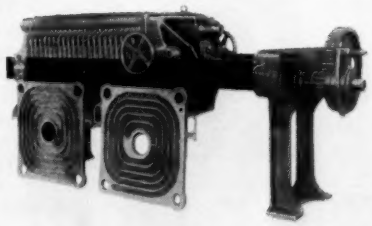
but primarily
WE SELL FILTRATION

The array of Shriver filters you see here represents various types we design and build for the process industries. But—more important—the kind of filter we recommend for your requirements is based on our technical investigations and laboratory tests to determine what is best suited for optimum operating efficiency and economy. Sometimes these analyses indicate the need for a filter not of our manufacture, and we tell you so frankly.

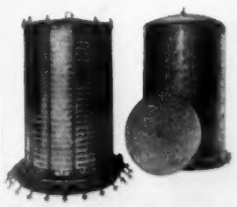
Such unbiased evaluations have helped build good will which our long experience has maintained at a high level.

That is why at Shriver's we try to "sell filtration," and the right filter for your process readily sells itself.

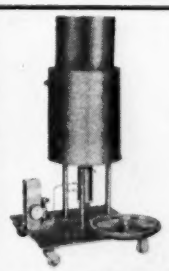
Let us work with you on your filtration improvement or expansion programs.



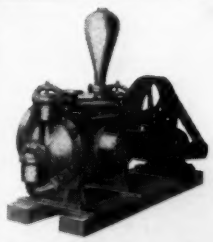
Continuous plate and frame slurry thickener and washer



Horizontal plate filter with hood type cover



Horizontal plate, tank type filter



Diaphragm pump for abrasive, corrosive materials

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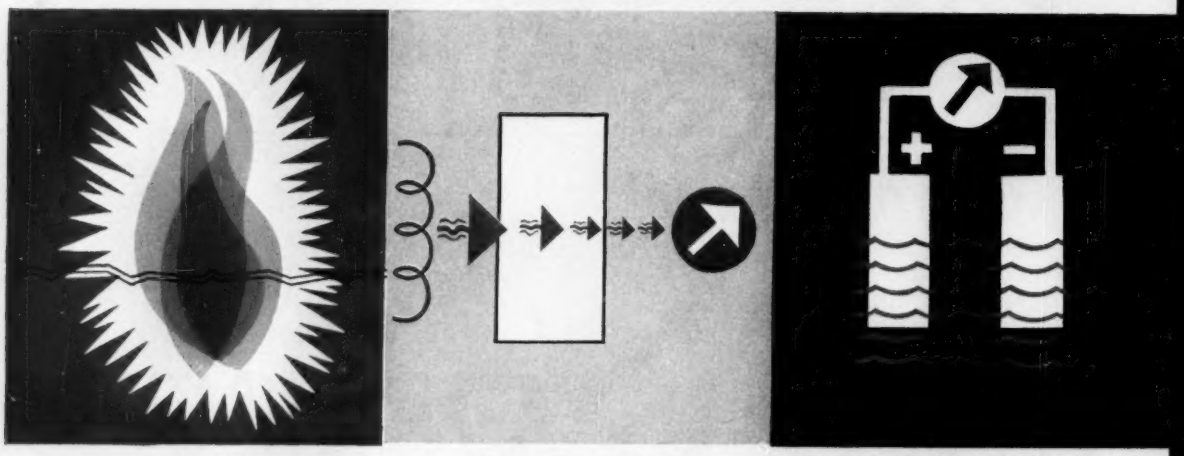
MSA Instruments apply all these principles



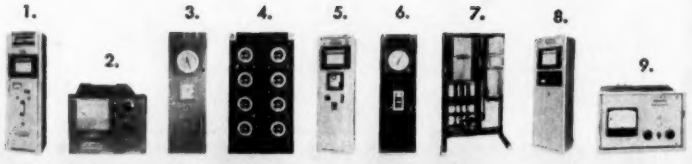
Catalytic Combustion **Infrared Analysis** **Depolarization**

MSA

INSTRUMENT DIVISION

Mine Safety Appliances Company

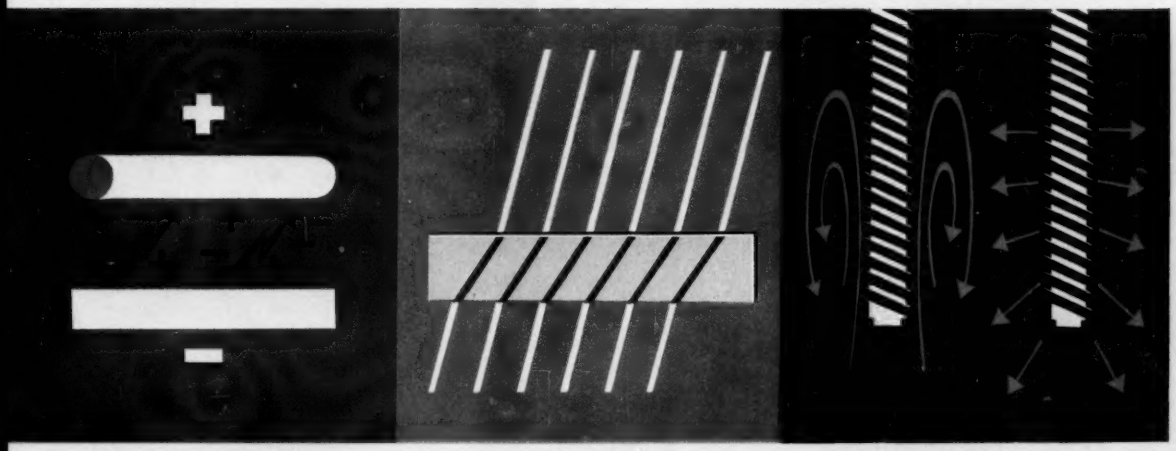
Pittsburgh 8, Pennsylvania



1. M-S-A® LIRA® Infrared Analyzer Model 200 **2.** M-S-A® LIRA® Infrared Analyzer Model 300 **3.** M-S-A® Inert Gas Analyzer **4.** M-S-A® Combustible Gas Analyzer **5.** M-S-A® Thermatron Analyzer **6.** M-S-A® Oxygen Indicator **7.** M-S-A® Water Vapor Recorder **8.** M-S-A® BillionAire* Analyzer **9.** M-S-A® Process Refractometer

*Trademark

for dependable process stream analysis



Ionization: Now MSA simplifies control of contaminants in the parts per *billion* to parts per million range. The new M-S-A® BillionAire* Analyzer is the hypersensitive instrument.

It's already at work in air pollution studies, process monitoring and continuous measurement of toxic gases in air.

Except when measuring oxygen in low concentrations, the instrument is sensitized for a specific problem by reacting the gas of interest with a reagent system to convert that gas to an aerosol. The aerosol passing through the ionization chamber changes its electrical conductivity which unbalances a bridge circuit in proportion to concentration. This in turn is indicated by an integral meter or recorder.

This same brand of instrument ingenuity is evident in all of the other techniques applied by Mine Safety Appliances Company. The versatility of these techniques is symbolized in the illustrative panel above.

One or more of these approaches could help you. Let's talk about your process problem. Invite an MSA Instrument Specialist to call. And write for new M-S-A BillionAire Analyzer bulletin or any of our other process stream analyzer literature.

Refraction

Thermal Properties

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American Optical

DURASAFE Mahogany with Mahogany side shields with Aluminum temples. Cat. No. F9800M

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Designed and built to provide the extra security that can never be measured in dollars and cents. Super Armorplate 6-curve lenses, frames, components of unquestionable quality.

UNEXCELLED FIT!

Durasafe provides the necessary bridge and eye sizes *to fit everyone* — with and without side shields — in safety Rx or plano glasses.

TOP WEARER ACCEPTANCE!

Pride of ownership and wearership. Durasafe is available in a variety of colors and combinations.

DURASAFE Black on Crystal with Aluminum temples. Cat. No. F9800BC

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- 7 Barrel Hinge — 40% increase in strength at a most vulnerable spot — where frame and temples are joined
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- "Lock-A-Lens" — New safety ridge locks lens in frame — locks trouble out.
- "Breeze Catcher" — new safety — comfort in non-reflecting mesh side shields
- Wider end pieces — stronger, sturdier frame — many other features

For Complete Details Write for Durasafe Catalog No. S-1013

American Optical COMPANY

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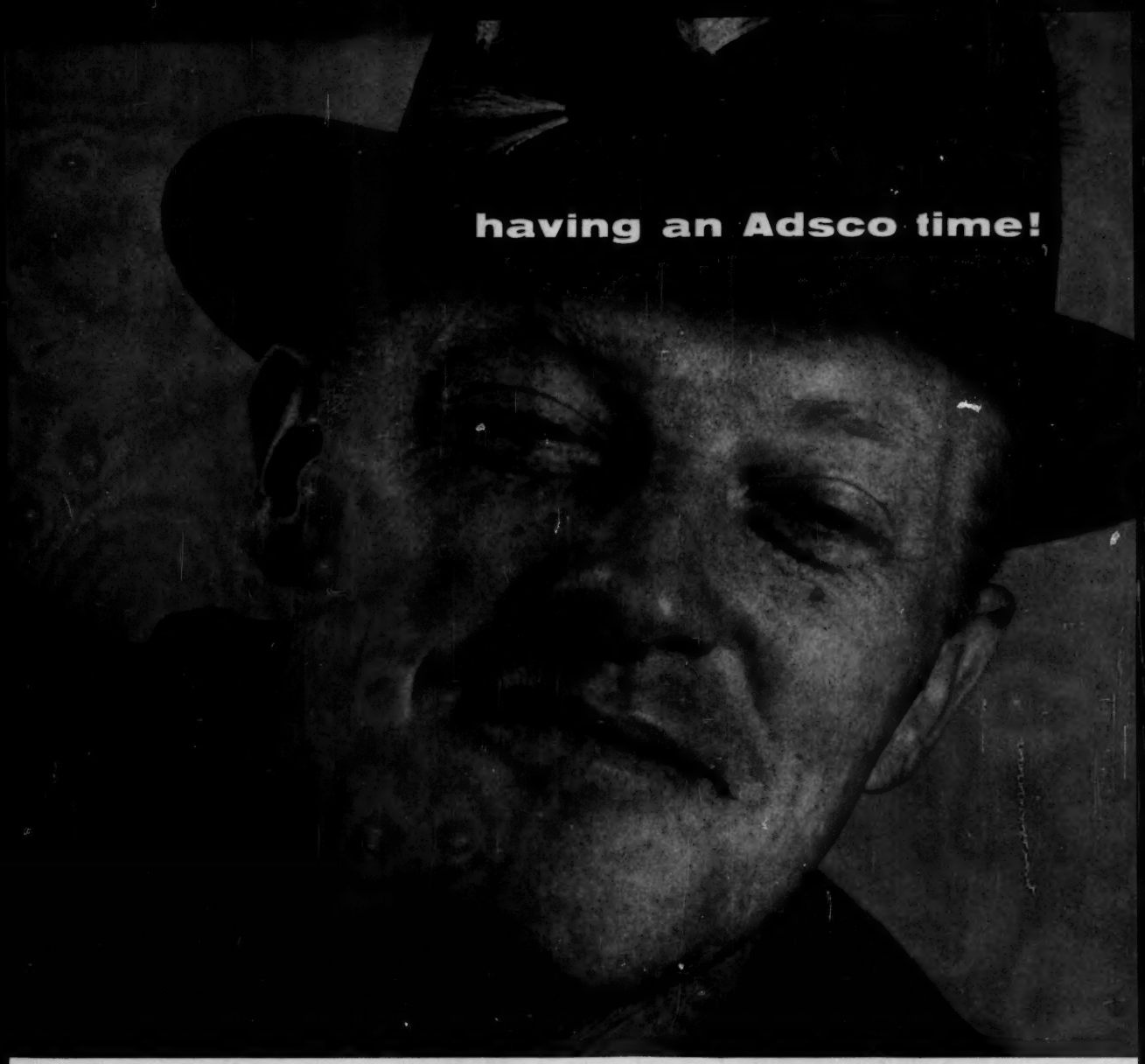

ONLY ADSCO HAS ALL 3 TYPES OF EXPANSION JOINTS

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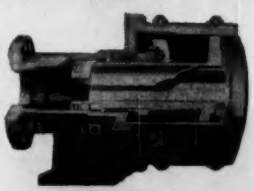

SLIP TYPE

...real peace of mind, the result of doing business with completely reliable Adsco. For more than 80 years, Adsco has carefully handled customers' expansion problems in their piping systems, from engineering through manufacture. Consult Adsco for your peace of mind.

Write for comprehensive catalogs

ADSCO ENGINEERED PRODUCTS

Sold, Engineered and Manufactured by

YUBA HEAT TRANSFER DIVISION

HONESDALE, PA.

World's Oldest and Largest Manufacturer of Packed and Packless Expansion Joints

YUBA

YUBA CONSOLIDATED INDUSTRIES, INC.

YUBA — A growth corporation serving growth industries

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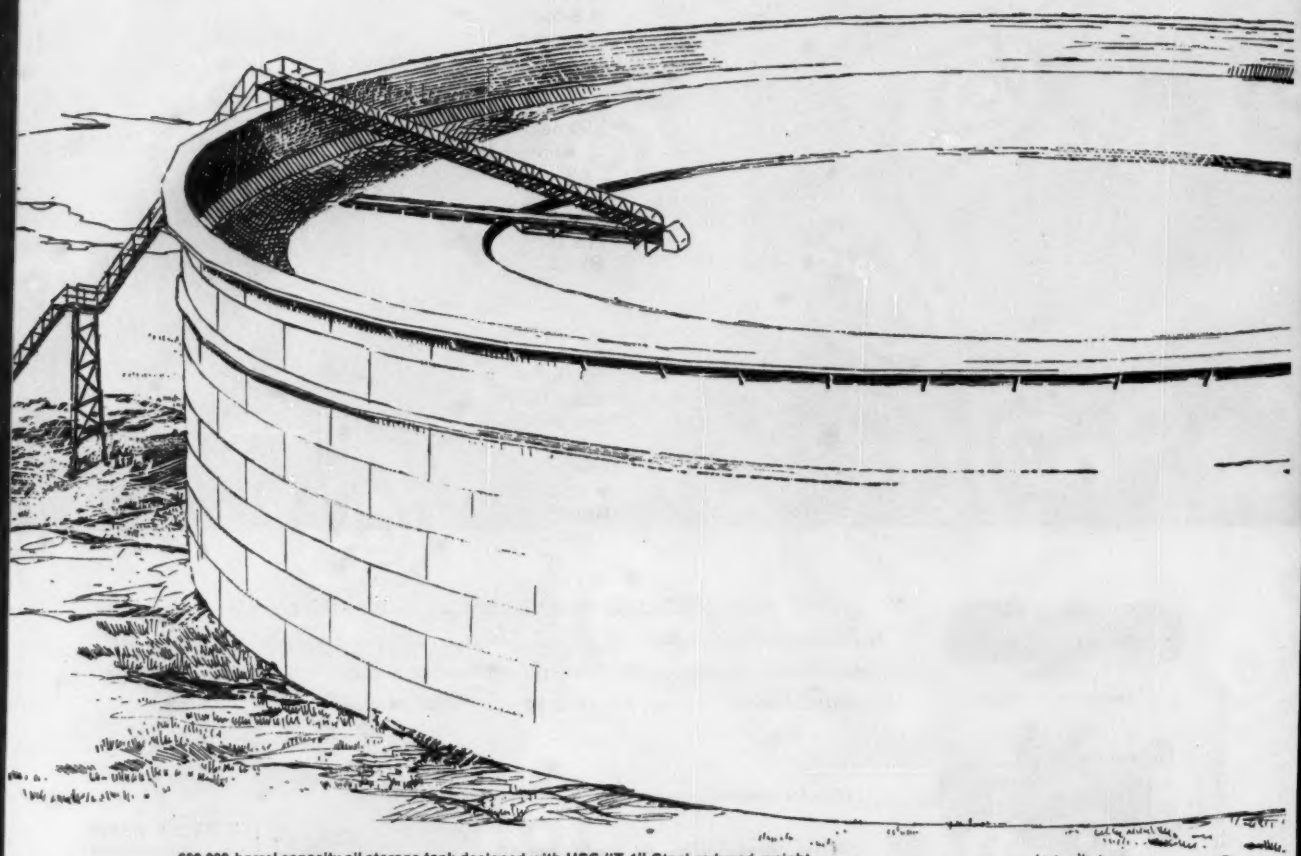
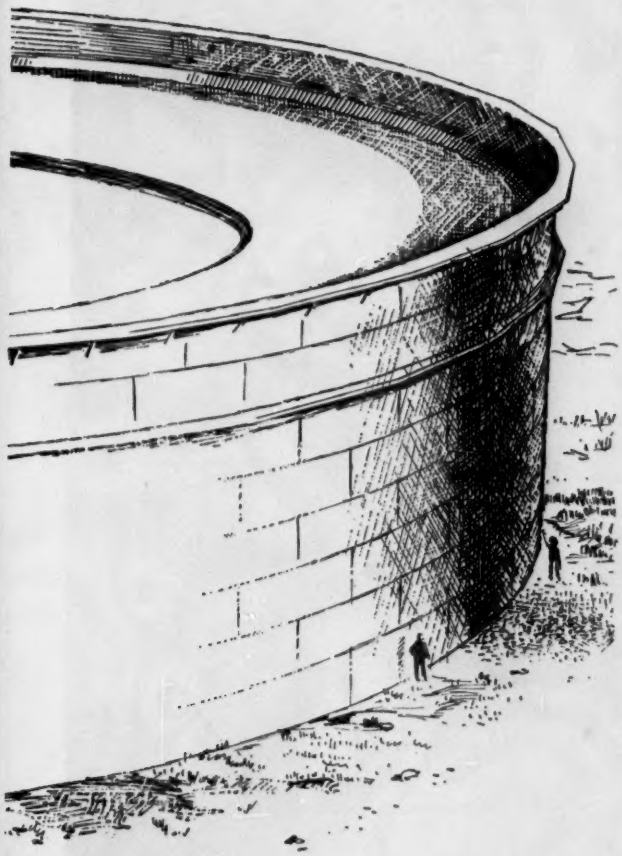
World's largest oil storage tank built of



600,000-barrel capacity oil storage tank designed with USS "T-1" Steel reduced weight by about 42%, with substantial savings in fabrication, freight and erection costs.

This mark tells you a product is made of modern, dependable Steel.

USS "T-1" Steel



A new 600,000-barrel oil tank 260 feet in diameter and 64 feet high has been erected for the American Independent Oil Company in Mena Abdulla, Kuwait, on the Arabian Gulf.

Kuwait is a petroleum paradise. In 1957, its oil production amounted to 56,000,000 tons, and it is still increasing. Most of the oil is exported and a giant storage tank such as this makes it possible to fill one of the new super tankers in one stop, rather than several.

The Chicago Bridge & Iron Company obtained the contract for the tank with a design that took advantage of the *extra* high strength of USS "T-1" Constructional Alloy Steel and its many cost-saving features.

The shell consists of six 8-foot rings of "T-1" Steel, made to 115,000 psi minimum ultimate strength, and two top 8-foot rings made of A 131 grade A carbon steel. The tank has a Horton pontoon floating roof and the bottom of the vessel was made of A 283 grade C plates ¼-inch thick.

USS "T-1" Steel reduces weight. The "T-1" shell thicknesses, which ranged from 1 inch down to ½ inch, were determined on the basis of a design stress of 38,333 psi. This is ⅓ of the minimum ultimate strength of the steel. Joint efficiency was calculated at 100%, with a product specific gravity of 0.90. The top two carbon steel rings were figured for the API 12-C allowable stress of 21,000 psi, with 100% joint efficiency, and with a product specific gravity of 1.0. Steel thicknesses were ½ inch and ⅜ inch.

Although API prohibits the use of carbon steel plates in the thicknesses that would have been needed for the 6 lower rings, by using USS "T-1", 42% less steel was required. Fabricating, shipping, and erecting costs were thus considerably lower than original estimates.

Lower maintenance, too! USS "T-1" Steel has four times the resistance of carbon steel to atmospheric corrosion. Research has shown that paint life is greatly increased on steels of this nature.

Other applications. Because of USS "T-1" Steel's exceptional strength and toughness, even at very low temperatures, it is the ideal material for pressure vessels, equipment hauling trailers, LP gas transports, offshore rigs and other equipment that must be built stronger but lighter. Write for a copy of our booklet, USS "T-1" Steel. United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS and "T-1" are registered trademarks of United States Steel
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United States Steel Corporation—Pittsburgh
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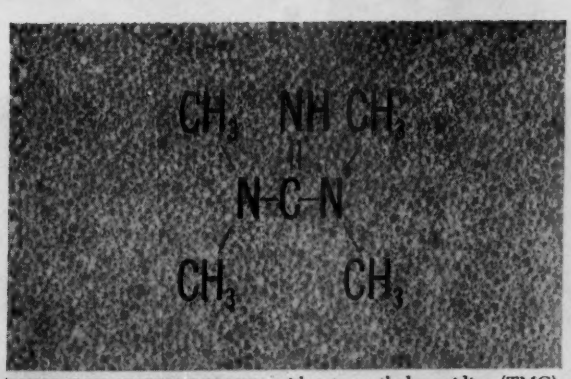
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

CYANAMID

Chemical Newsfront

"ANTI-SUNBURN LOTION" FOR PLASTICS provided by Cyanamid's new CYASORB® UV 314 ultraviolet light-absorbing chemical. *Left*—A month in the Arizona sunlight renders a sample of polyethylene brittle as an eggshell. *Right*—When protected with only 0.5% Cyasorb UV 314, the same plastic remains flexible even after *four* months in the same sunlight. Cyasorb UV 314 works same wonders for polypropylene. Fiber, sheet, film, and molded plastics can now be light-stabilized. **(Intermediates Department)**



BETTER RIGID URETHANE FOAMS—with tetramethylguanidine (TMG). Kinetic studies show TMG favorably active on price-performance basis in catalyzing primary and secondary hydroxyl reaction with NCO. Anticipated advantages include ease of handling, better cross-linking, minimum odor in final product, and possibly improved aging under high humidity. **(Market Development Department)**

NEW SALES APPEAL FOR ACRYLIC FIBERS! Five Cyanamid CALCOZINE* acrylic dyes have a history-making new look. They require no expensive retarders—no modifications that weaken light fastness. In addition they permit ease of application, simplified leveling and stripping, deep penetration and high spotting resistance. Versatile, they work well with true or modified acrylics on all types of dyeing equipment. *Trademark **(Dyes Department)**

ON THE CARPET! Cyanamid's ANTIOXIDANT 2246® forms only a small, but vital, part of the latex backing that locks carpet loops in place. It prevents oxidation, keeps rug coatings free of brittleness and cracking, and minimizes discoloration.

(Rubber Chemicals Department)

For further information on products in this advertisement, wire, phone—or mail this coupon to: CE-100

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30 Rockefeller Plaza, New York 20, N. Y.

Please send me additional information on

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- ☐ TMG
- ☐ ANTIOXIDANT 2246
- ☐ CALCOZINE ACRYLIC DYE

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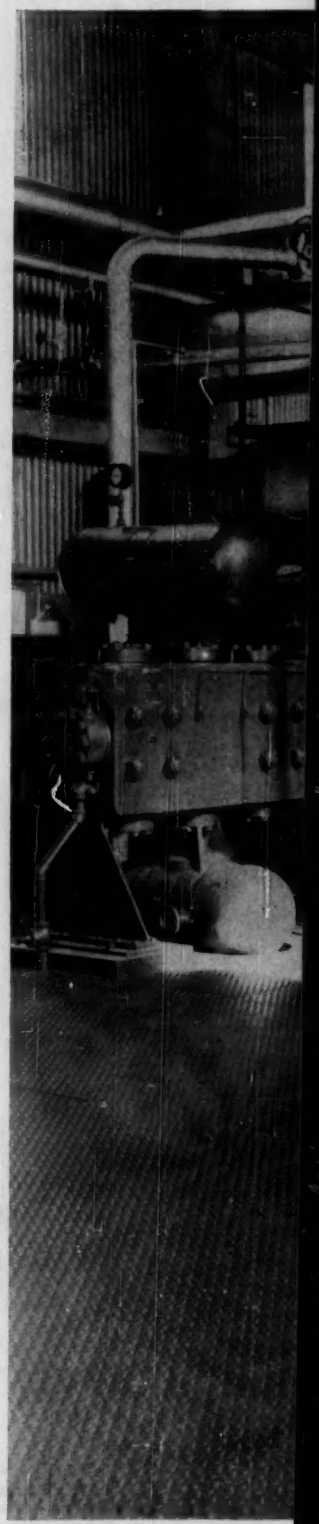
City_____ Zone____ State_____

CYANAMID

AMERICAN CYANAMID COMPANY
30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

Noel M. Champion *(left), Chief Engineer, Armour Agricultural Chemical Company, discusses a technical problem with* Robert L. Kietzman, *Sales Engineer, The Cooper-Bessemer Corporation, St. Louis District Office.*



How Cooper-Bessemer service helps keep the ammonia flowing

At Armour Agricultural Chemical Co., Crystal City, Missouri, nine Cooper-Bessemer compressors play key roles in the manufacture of ammonia products. Round the clock, for five years, these units have given exceptional performance under the rigors of such problems as handling pressures up to 9000 psi.

The performance of these C-B compressors has been backed by Cooper-Bessemer engineers in the St. Louis area and in Mt. Vernon, contributing helpful service for these high-pressure operations.

Cooper-Bessemer engineers will gladly help *you* plan compression facilities, and demonstrate how this unique service works for your benefit. Call the nearest office.

BRANCH OFFICES: Grove City • New York • Washington • Gloucester Pittsburgh • Detroit • Chicago • Minneapolis • St. Louis • Kansas City • Tulsa New Orleans • Shreveport • Houston • Greggton • Dallas • Odessa • Pampa Casper • Seattle • San Francisco • Los Angeles • *SUBSIDIARIES:* Cooper-Bessemer of Canada, Ltd.... Edmonton • Calgary • Toronto • Halifax Stratford • C-B Southern, Inc.... Houston • Cooper-Bessemer International Corp.... New York • Caracas • Anaco • Cooper-Bessemer, S.A.... Chur, Switzerland • The Hague, Netherlands • Mexico City • The Rotor Tool Company... Cleveland

Cooper Bessemer

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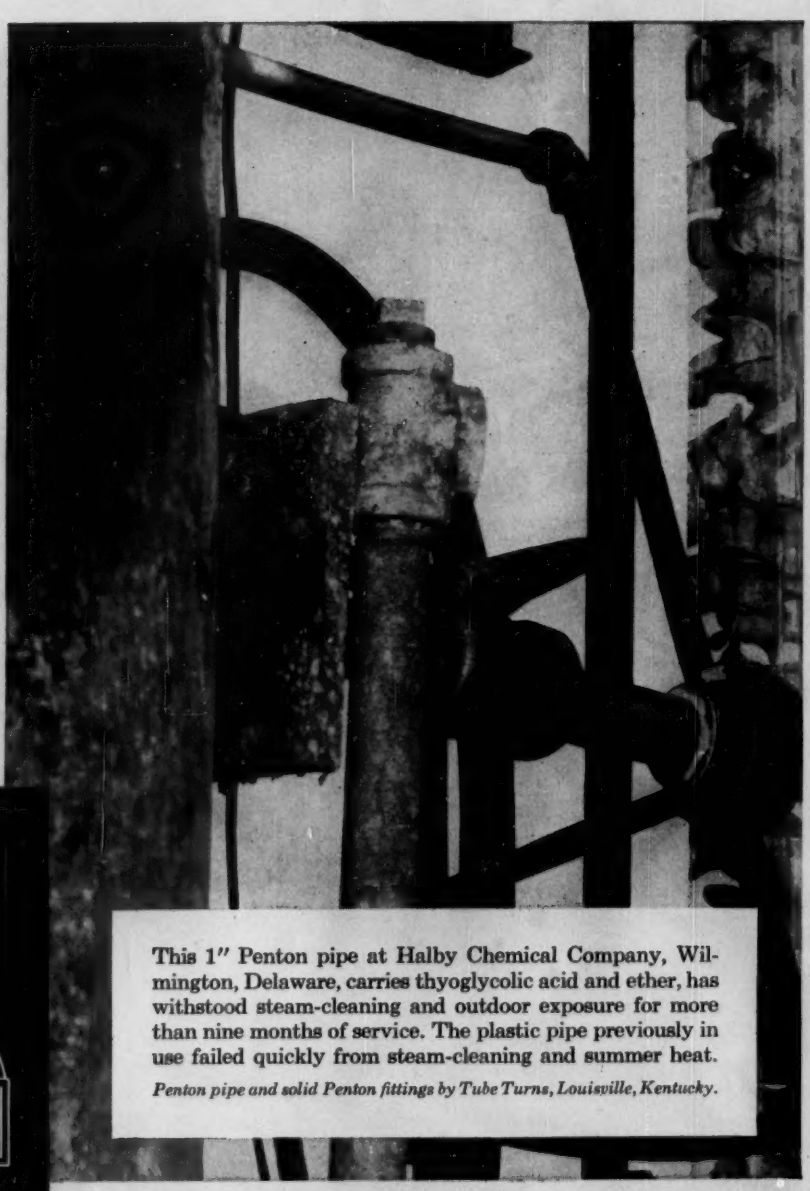
ENGINES: GAS - DIESEL - GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE, TURBINE OR MOTOR DRIVEN

Noel M. Champion *(left)* and Thomas H. Ferebee, *Supt. Ammonia Plant. In background are two GMWA-10, four GMWA-8 and one GMWA-6 engine driven compressors for compression of air, natural gas, synthesis gas and ammonia. Armour also has two FM compressors for ammonia recirculators.*

WHICH PENTON* PIPE

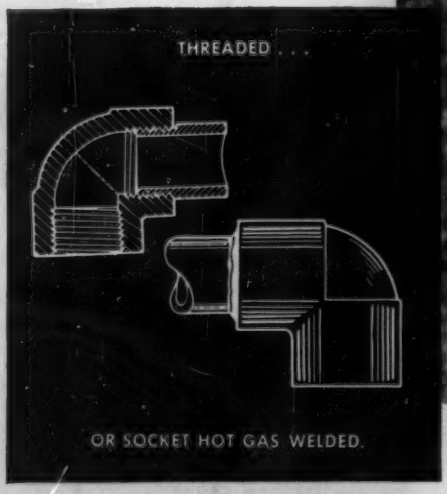
SOLID
PENTON PIPE:

A rigid, uniform pipe produced by extrusion, and available in sizes from ½″ to 2″ in either Schedule 40 or Schedule 80, in lengths up to 20 feet. Use in conjunction with injection molded, solid Penton fittings with socket or threaded connections (see diagram below). Provides both interior and exterior high temperature corrosion control. Today's most versatile, all-plastic pipe.



This 1″ Penton pipe at Halby Chemical Company, Wilmington, Delaware, carries thyoglycolic acid and ether, has withstood steam-cleaning and outdoor exposure for more than nine months of service. The plastic pipe previously in use failed quickly from steam-cleaning and summer heat.

Penton pipe and solid Penton fittings by Tube Turns, Louisville, Kentucky.



COMPLETE CORROSION CONTROL

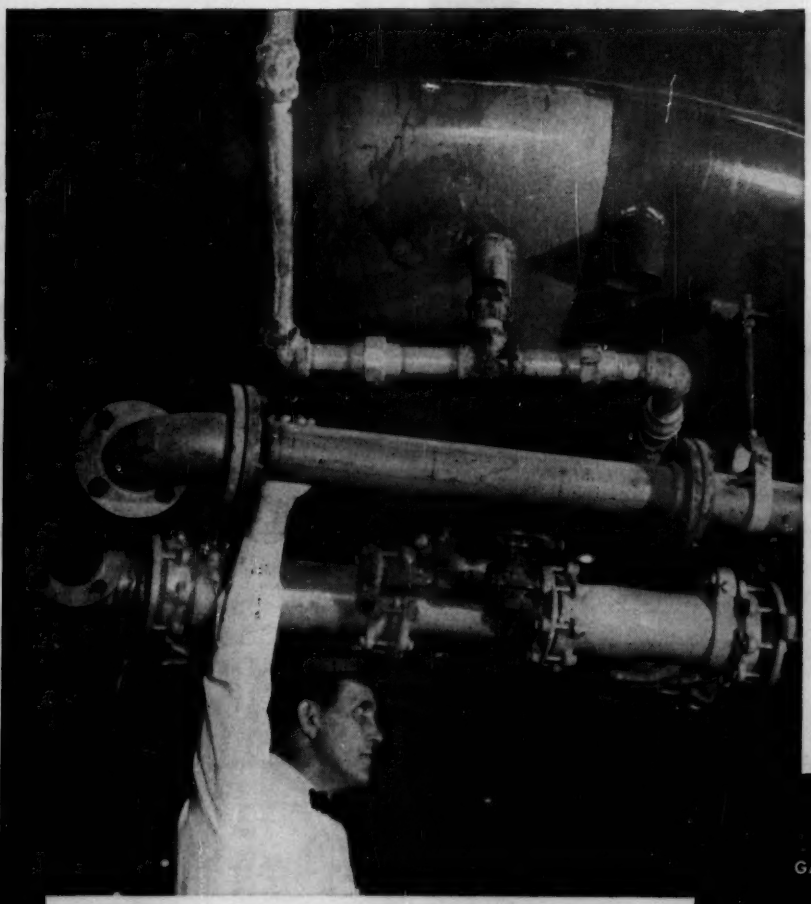
Inside and outside

High temperature resistance to a broad range of chemical reagents
Easily fabricated
Resistant to chemical atmospheres

Penton pipe and fittings, used in combination with other readily available Penton components for chemical processing, now make it possible to design a complete anti-corrosion system based on this versatile high temperature thermoplastic. Write for your copy of "The ABC's of Penton for Corrosion Resistance," which rates Penton's performance when ex-

**Hercules trademark for chlorinated polyether*

IS BEST FOR YOU?

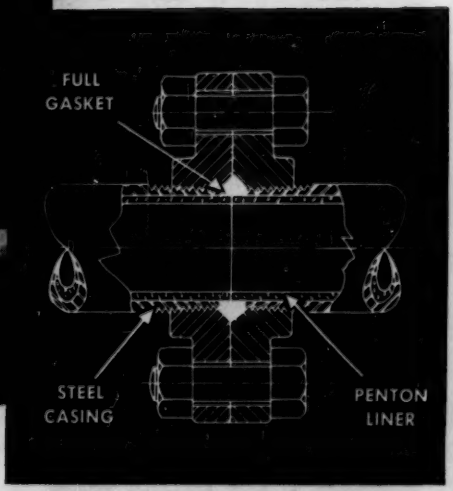


This 3″ Penton-lined pipe carries a chlorinated product in carbon tetrachloride, 0.1% to 3% hydrogen chloride, less than 0.1% chlorine, and occasional saturation with water, at temperatures ranging from 165°F. to 185°F. It shows no change after more than 10 months in continuous use.

Penton-lined pipe by Saran Lined Pipe Company, Ferndale, Michigan.

LINED PENTON PIPE:

Steel pipe with a heavy Penton lining, available in sizes from 1″ to 6″ I.P.S. outside diameter, in lengths up to 10 feet. Joined by flanged gasket connection (see diagram below), it can be cut and fitted in the field without difficulty. Combines the outstanding high temperature, corrosion resistance of Penton with the structural strength of steel.



posed to over 280 different chemicals and chemical reagents. Complete information on current sources for Penton products is listed in "The Penton Buyer's Guide," also available upon request.

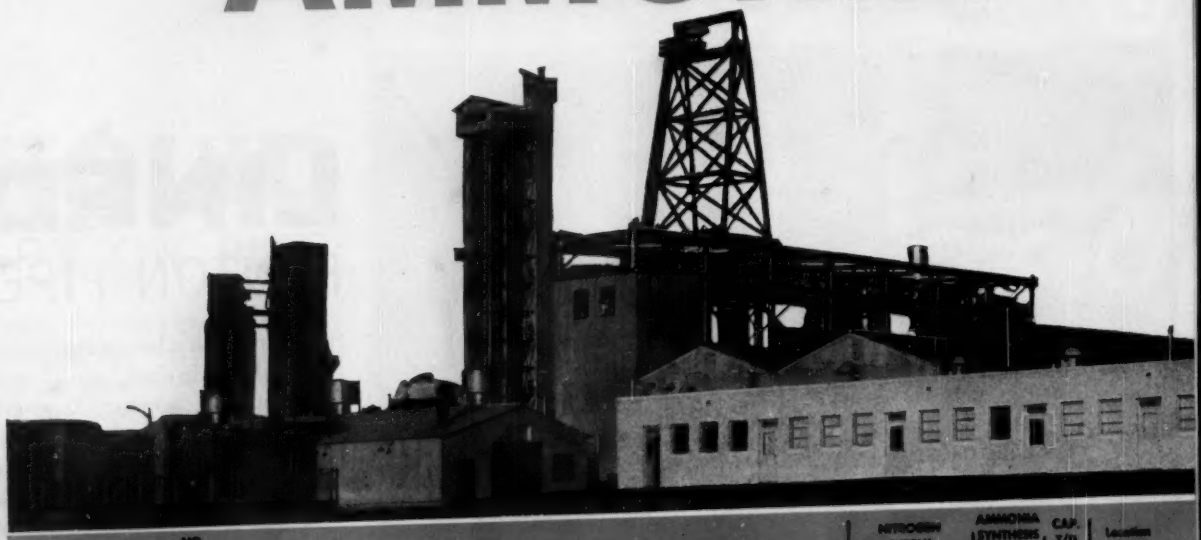
THE STRENGTH OF STEEL
and the properties of Penton
Excellent corrosion resistance at elevated temperatures
Economically installed
Safe, durable, and strong

Cellulose Products Department

HERCULES POWDER COMPANY
INCORPORATED
Wilmington 99, Delaware

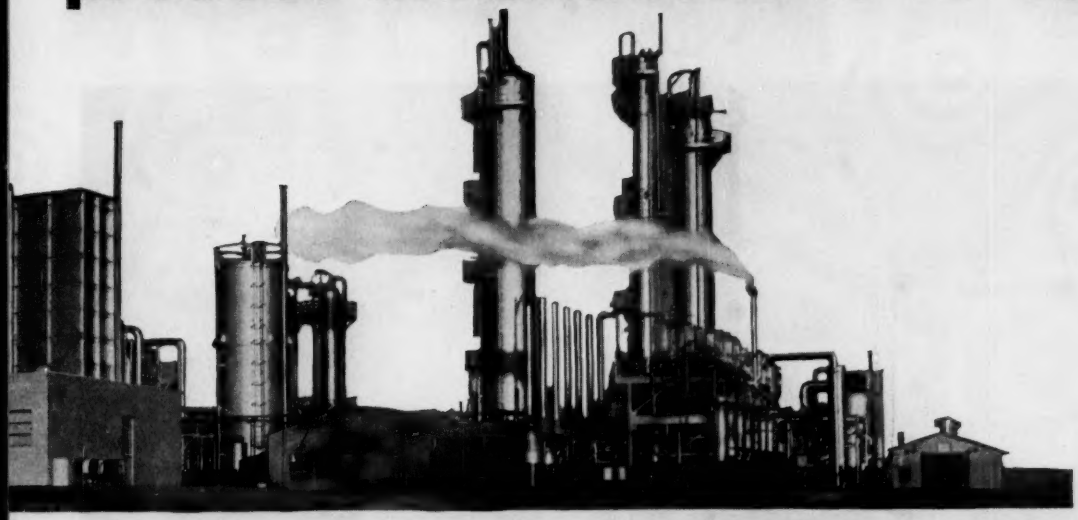
CP60-6

AMMONIA



FEED	NO. OF PLANTS	HYDROGEN PRODUCTION	NITROGEN SUPPLY	AMMONIA SYNTHESIS PROCESS	CAP. T/D	Location
BY-PRODUCT HYDROGEN	1	Oxygen Removal; NaOH Scrubber	Air Separation; Air	Casale	60	Michigan
ACETYLENE PLANT TAIL GAS	1	H_2O; Shift Conversion; CO_2 Removal; Liquid Nitrogen Wash	Air Separation; Air	Casale	110	Texas
HYDROGEN-RICH REFINERY OFF-GAS	2	H_2S Removal; CO_2 Removal; Low-temperature Purification; Liquid Nitrogen Wash	Air Separation; Air	2 Casale	300 180	Louisiana Illinois
NATURAL GAS (a)	5	Partial Oxidation; Shift Conversion; CO_2 Removal; Liquid Nitrogen Wash	Air Separation; Air	4 Casale 1 Other	210 (b) 230 300 180 100	Mississippi Oklahoma Tennessee Kansas Brazil
OIL	2	Partial Oxidation; Carbon Removal; Shift Conversion; CO_2 Removal; Liquid Nitrogen Wash	Air Separation; Air	2 Others	110 (b) 120 (b)	Japan Japan
OIL (HIGH SULFUR)	2	Partial Oxidation; Carbon Removal; Sulfur Removal; Shift Conversion; CO_2 Removal; Liquid Nitrogen Wash	Air Separation; Air	1 Other	360 (b) 330	Spain Italy
NATURAL GAS	2	Steam; Air; H_2O; H_2S Removal; Steam Reforming; 1st Stage Shift Conversion; CO_2 Removal; 2nd Stage Shift Conversion; CO_2 Removal; Methanation	From Secondary Reforming	2 Casale	300 115	Indonesia Iran
TOTAL	15	(a) Purification before oxidation not normally required. (b) Synthesis gas.			2985	

process installations 1945-1960



Worldwide experience with six feeds utilizing seven process sequences to produce ammonia

More than one million tons per year ammonia capacity has been built or is under contract by Foster Wheeler. Eight Foster Wheeler plants account for 20% of the tremendous increase in the production of ammonia in the United States over the last decade. The table at left provides a brief view of FW's process flexibility and worldwide experience.

The most recently completed FW ammonia plant exceeded rated capacity within one month of start-up. Economic production over a wide range of outputs has been realized. From plants of modest size, to those in the higher capacity ranges, these Foster Wheeler ammonia plants turn in exceptional performances.

Foster Wheeler has also designed and constructed two of the largest urea plants in the United States. Both use the Pechiney-Grace process featuring total recycle and produce urea of superior quality and color. To get information on the ways Foster Wheeler process experience can serve you, write to Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, New York.

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FOSTER WHEELER

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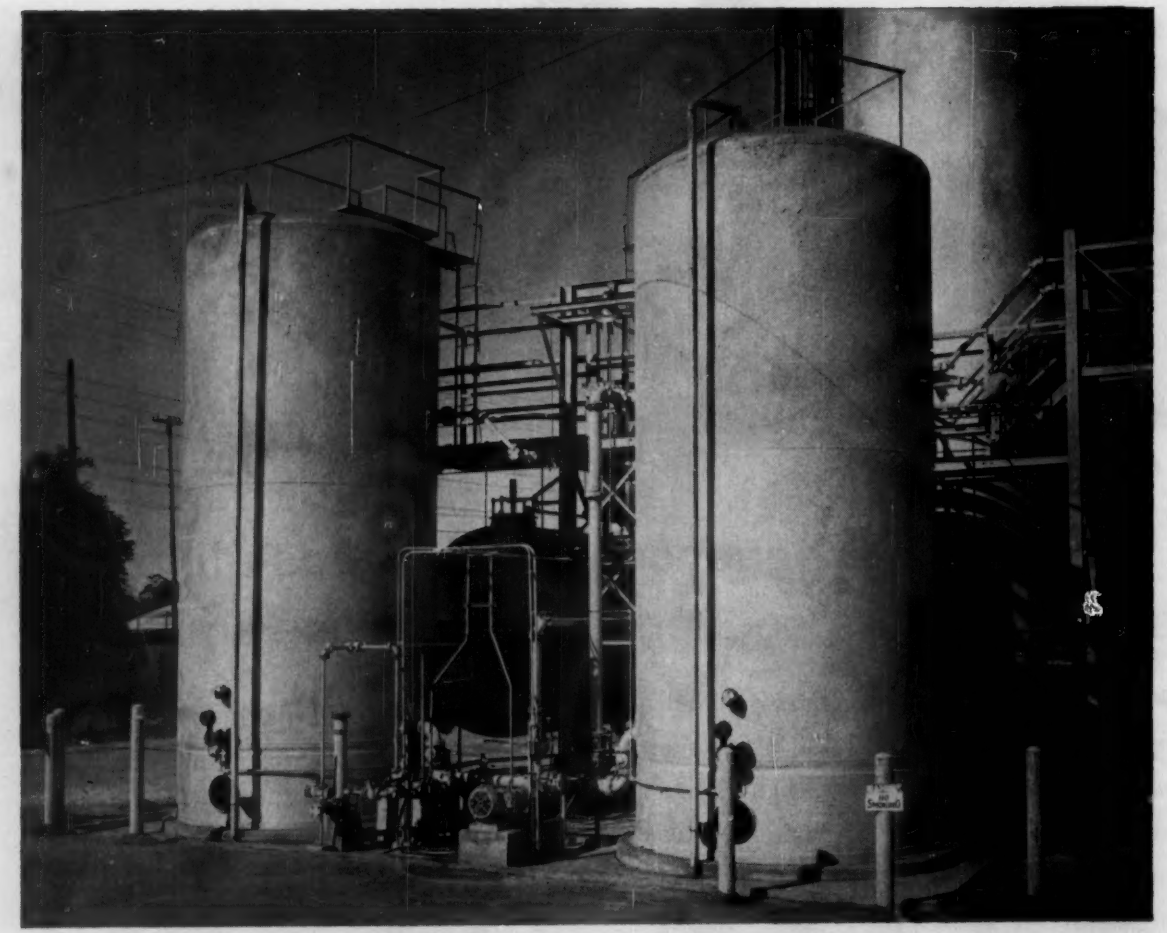
FLUIDICS* AT WORK



Glasteel takes the bite out of corrosive chlorine dioxide at Scott Paper Company's mill in Mobile, Alabama.

How to profitably end corrosion in every phase of ClO_2 generation

If you examined these tanks for dissolving and storing sodium chlorate, you'd find no evidence of corrosion at the constantly shifting liquid-air interface.

Combination of materials is the reason. These are Pfaudler® Glasteel tanks—*steel* outside for strength, *glass* inside for corrosion resistance. And there is no rust contamination of the chlorate, which can cause troublesome "puffs."

Glasteel towers and pumps. These tanks plus towers, pumps and ClO_2 storage tanks are part of the chlorine dioxide system at Scott Paper Company in Mobile, Alabama. In operation for over 15 months now, there has been no evidence of corrosive attack in any part of the system where Glasteel has been used.

Economy the key. You will also find Glasteel equipment in 38 other progressive pulp mills. And, whether the Solvay or Olin Mathieson process is used, the reports are still the same: Pfaudler Glasteel turns out to be the *most economical* equipment available, in terms of cost, maintenance and service life.

Complete systems. With this experience and our Project Engineering service, Pfaudler offers you or your engineering firm complete plant design, procurement and installation for ClO_2 generating systems.

More information. For details, or answers to specific questions, please write to the address shown on the facing page.

How to test the value of Glasteel polymerizers

Consider three important factors — purity of the polymer, amount of downtime, and initial cost. Then, look at what you can expect from Pfaudler Glasteel polymerizers.

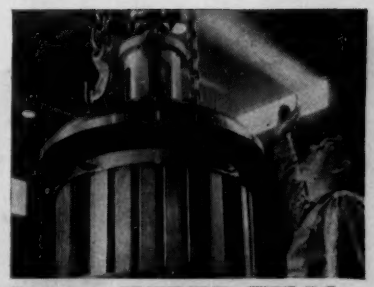
Product purity. Glasteel will not contaminate or discolor materials you use in making synthetic resins. Nor will it act as a catalyst to set off undesired side reactions.

Naturally, you also get Glasteel's unmatched acid-alkali corrosion resistance, so you can project a long service life for this equipment.

Reduced downtime. Glasteel has an abrasion-resistant, smooth surface — smoother than the most highly polished metals. So even sticky substances don't adhere readily. What little does, you wash away quickly between batches, using the Pfaudler glassed Spray Rinse Valve. Thus you can expect to put through more product per day.

Lower cost. Glasteel costs less—significantly so—than the alloys you probably would consider in order to protect your product's purity. Just how much you can save will be apparent after you have had a chance to discuss your needs with one of our representatives.

Complete specifications and operating characteristics are covered in Bulletin 932. We'll be happy to send you a copy.



Does a WIPED FILM evaporator fit your process?

Yes, if you evaporate products that are
(1) heat sensitive, or
(2) highly viscous, or
(3) low in thermal conductivity.

What makes the Pfaudler Wiped Film Evaporator so well suited is the *mechanically wiped* evaporating surface.

It works like this: Centrifugal force of an internal rotor (pictured at left) holds four free-floating wipers in contact with the evaporator wall. These wipers spread your product out over the entire evaporating surface in a *thin, uniform* film. Slots in each wiper prevent product "curl" forward of the wipers and accelerate product movement down the wall.

Since the heated wall is kept completely wet, you are sure of maximum heat transfer — a very important consideration with viscous and heat-sensitive materials, or those with low thermal conductivity.

Test, anyone? In our Test Center we maintain a 4-square-foot Wiped Film Evaporator for product evaluation studies.

Production units offer 4 to more than 100 square feet of evaporating areas. (That's a 50-square-foot one being assembled in the picture.)

We'd be happy to send you detailed specifications or provide further information about the test program.

Four easy steps put F-C Glasteel Pipe* in your plant

Here's a corrosion-resistant, high-integrity lined pipe that's literally as easy as 1-2-3-4 to install.

Just take a section of Pfaudler F-C Glasteel Pipe (the F-C means "field cut") and cut to the length you want on a standard, dry abrasive cutoff wheel.

Next, thread—just as you see in the picture.

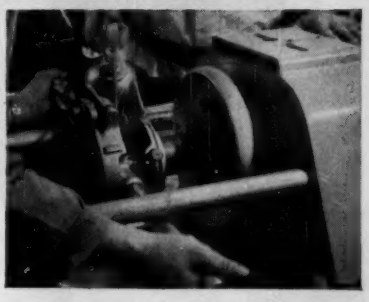
Third step: Fire-polish with a small, portable furnace. (You can get one from Pfaudler at modest cost that you will recover through the savings from a few installations.)

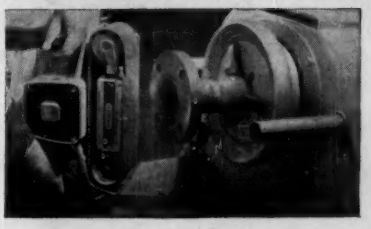
Then, thread on flange and belt sand to assure that gasket seat is flat and the flange connection seal-tight.

For complete details, ask for Bulletin 989.

Address all inquiries to our Pfaudler Division, Dept. CE-100, Rochester 3, N. Y.

*Patent applied for





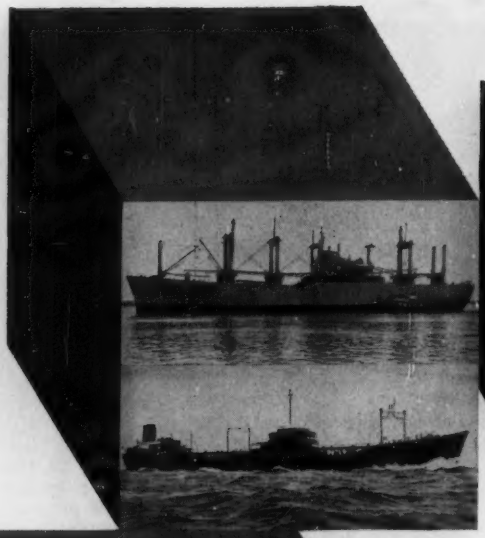
FLUIDICS AROUND THE WORLD

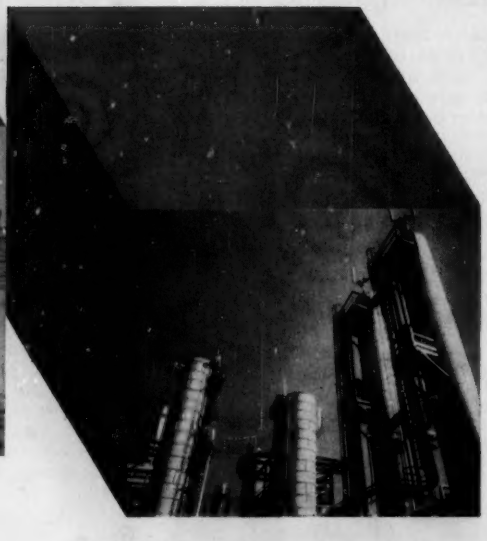
Pfaudler Permutit is a world-wide company with manufacturing plants in: Germany, Great Britain, Canada, Mexico and Japan, as well as four plants in the U. S. A.

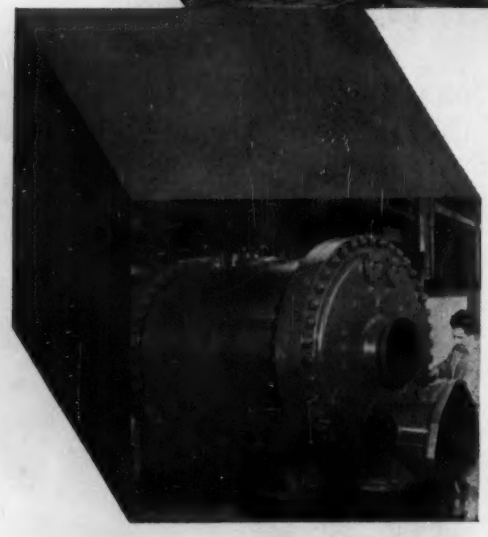
*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes







SUN SHIP built 'em all....

Our reputation as "master builders for land and sea" is based on 44 years' service to the oil-refining, chemical and other industries.

Frequently we are called upon to produce components for the building of large plants. Our manufacturing and fabricating skills, our understanding of industry's problems are reflected in the variety of equipment we build, like the fractionating towers and special pressure vessel shown here.

In our complete, modern shops we build and *deliver* what's needed in many fields. Our special Alloy Products Shop, for example, is equipped to produce medium and heavy stainless alloy and aluminum products for industry.

Building for land • Pressure vessels • Fractionating towers • Stills and tanks • Condensers and similar equipment • Special machinery • Plate work, etc.

Building for sea • Dry cargo ships • Tankers • Marine repairs • Dredges • Ferries • Marine engines • Marine machinery.

Sun Ship does a big job for many companies, and can do the same for you.

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$CH_2:CHCl$
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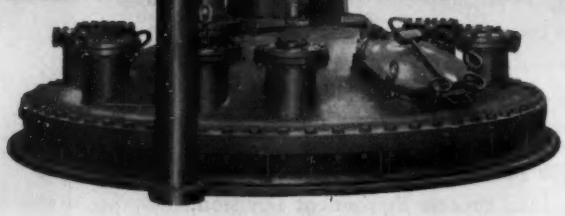
Corrosive acids or just plain water... abrasive slurries or radioactive fluids... Lapp Pulsafeeder pumps them all safely, meters them precisely, completely eliminates leakage and contamination. And you can fit the pump to your specific process from today's most complete line: metered flow rate from a few drops to 15.7 gallons per minute; pressures up to 7000 psig.; manual or instrument controls. Which for you?
WRITE for new Catalog 59. Lapp Insulator Co., Inc., Process Equipment Division, 1110 Poplar Street, LeRoy, N. Y.
Lapp

YOU GET MORE...WHEN IT'S A PHILADELPHIA MIXER!



YOU GET MORE because Philadelphia Mixers are huskier. All components are heavier duty, higher capacity.

YOU GET MORE because the integrated design of Philadelphia Mixer drive assemblies makes optimum use of the high quality and extra capacity of all components. Result: Improved mixer performance . . . longer mixer life . . . reduced maintenance costs.

CASE IN POINT: Hundreds of Philadelphia Mixers installed at Toms River-Cincinnati Chemical Corporation, major producer of dyes, have produced solid, over-the-years savings through rock bottom maintenance costs and 100% availability. This includes mixers with horizontal motor drives that solve headroom problems . . . mixers with vertical motor drives that simplify tank top piping arrangements . . . mixers with variable speed drives that meet changing process needs . . . and special mixers with push button controlled impeller raising and lowering devices.

When you buy Philadelphia Mixers you get still another advantage . . . precision ground gearing in the mixer drives. This is a major advance in gear accuracy that means less wear, less vibration and reduced sound levels.

Look into all the advantages of Philadelphia Mixers. Six standard models, 1 to 250 HP. Special units to 500 HP. Horizontal or vertical motor drive. Mechanical seal or packed stuffing box. Paddle or turbine type impellers. For complete data, write for catalog A-19.

philadelphia mixers

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You may not wish to bake a cake with Wyandotte Bicarb. But you can (as many leading baking companies do). And each time you bake, the result will be uniformly the same. Point is, you can always trust the uniformity of Wyandotte Bicarb—in whatever way you use it. The reason: Over 70 years of manufacturing experience? Yes, that helps. But even more important is our more-than-70-year record of working with the bicarb-consuming industries to see that each user gets the proper grade to meet his needs exactly. Why don't you try...

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Top news stories and what they mean to CPI technical decision makers

Chementator

Three U. S. firms now spinning new rayon-that's-not-rayon

With an eye on the upcoming spring garment season, several rayon producers are hurrying to achieve a fully commercial status for new high-wet-modulus (polynosic) cellulose fibers:

• Hartford Fibres has just started up its Zantrel polynosic fiber plant at Rocky Hill, Conn. Facility has a 15-million-lb./yr. capacity, can be expanded to 30 million lb./yr.

• Courtaulds (Ala.) is just bringing on stream a unit of undisclosed capacity in Mobile, Ala., to produce its version of high-modulus cellulosics under the trade name Moynel.

• American Viscose has commercialized its experimental Fiber 40 under the Avril trademark, is now in production at three locations: Nitro, W. Va.; Parkersburg, W. Va.; Front Royal, Va.

Object of all this activity: to capture some of cotton's markets in the face of mounting competition from other synthetics and dwindling markets for cellulosics in other areas, notably tire cord. New high-modulus fibers differ considerably from ordinary rayon, can be mercerized, stabilized by compressive shrinking and can be made crease-resistant without loss of strength that occurs in cotton fabrics.

In related developments, Courtaulds (Canada) says it will import Moynel from its parent company in England for marketing in Canada until demand warrants setting up a plant at Cornwall, Ont. Although Moynel is being produced in England, Courtaulds says it cannot be considered commercial there. Rayon is not as beleaguered by other synthetics in England as it is in the U. S., so parent Courtaulds is not pushing the improved rayons as hard as are its North American subsidiaries.

American Enka says it is still experimenting with its high-modulus Fiber 500, but has no commercial plans at present. It says it still is not sure whether a high-modulus fiber or a cross-linked fiber (such as Courtaulds' Corval and Topel) or a combination of both techniques is the best answer to rayon's current market dilemma.

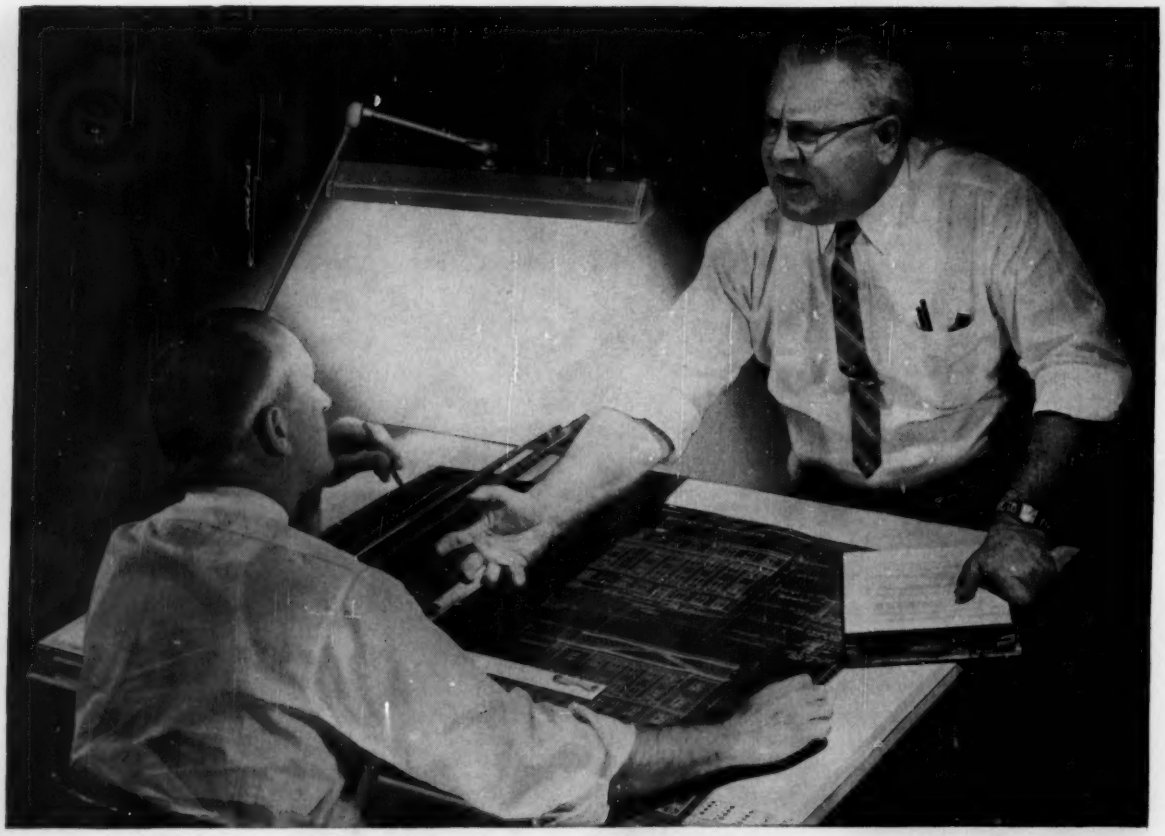
Confirming industry speculation, Linde Co. says it will market high-purity oxygen and nitrogen via pipeline from a central plant in the Houston Ship Channel area. First customers: Armco Steel and Diamond Alkali, both of which will tap off an 8-mi. line.

Don't bother to weld that pipe; it's probably cheaper to glue it

A development in pipe joining, now in use in the gas fields of the southwest, may soon be affecting the whole chemical industry. Tex-Tube, Inc., Houston, Tex., has invented a way to glue steel pipe with epoxy cement instead of using conventional welding techniques. Result: reduced installation time and lower costs.

Process has been field-tested for over a year on lines carrying salt water, oil and natural gas in thin-wall (about 0.1 in. thick) lines ranging from 1½ to 4½ in. dia. One end of the pipe is enlarged slightly so that it overlaps the end of the next section by about 4 in. Inside of the enlarged section and the straight end of next length are both coated with epoxy adhesive, the two ends fitted together and a patented hydraulic crimping tool applied. After crimping, joint is taped. Total elapsed time: under 2 min.

Glued joint takes about 48 hr. to come to full strength, after which a 3-in. line can withstand a 1,200-psi. working pressure and a 4-in. line withstands about 800 psi. Tex-Tube claims that use of the special thin-wall pipe cuts pipe costs as much as 58% while the new joining technique shaves installation



"Explosion-proof **EXIT** *signs!*

***Where** do you expect me to get them ?"*

As you can see, they found the explosion-proof exit sign. It's Crouse-Hinds No. EVA139.

Look in your Crouse-Hinds catalog, of course. There's nearly everything you could want for hazardous areas listed there. Nine different types of explosion-proof telephones... horns, bells, clocks, pilot lights, instrument enclosures, gauge lights. Even X-Ray film illuminators. And, of course, modern designs in all the familiar explosion-proof motor controls, switches, plugs, receptacles, panel boards and lighting fixtures. UL-listed for every Class and Group in Article 500, National Electrical Code.

So, whether you're looking for conventional or out-of-the-ordinary explosion-proof electrical devices, contact Crouse-Hinds. If you design, buy or work with hazardous-area equipment, a Crouse-Hinds catalog should be on your desk. Ask your Crouse-Hinds Representative.

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charges as much as 25%. As a bonus, the epoxy-joined lines stand up better in corrosive service than welded pipe.

Although oil and gas pipeliners have been the first to experiment with this new method, several chemical processors are now evaluating it for possible in-plant use. Plastic-coated thin-wall pipe, for example, might be able to replace more expensive stainless and alloy piping in corrosive service.

A few details on the new Pechiney-Ugine aluminum production process have been divulged. Process involves two-stage carbothermic reduction of bauxite, yielding aluminum with lower Ti content than conventional material. The 5,000-ton/yr. pilot unit being erected at Nogueres, France, will employ a 10,000-20,000-kva. reduction furnace.

What next? Engineers call pay hike an unfair labor practice

Boeing Airplane Co. recently gave its engineers an across-the-board 3% pay increase—and was immediately accused of an unfair labor practice by the Seattle Professional Engineering Employees Assn. (SPEEA) that represents the engineers.

This incident is not quite as bizarre as it sounds, however, in light of what preceded the pay hike. In negotiating sessions with SPEEA, Boeing offered to raise all engineers' salaries by 3%. Union membership rejected this offer by an 87% majority because it departed from the four-year pattern under which salaries have increased by the same percentage as salaries paid beginning engineers. Union also claimed new contract's layoff provisions would have impaired hard-won job security.

After Boeing's unilateral action in raising salaries by 3% in spite of the union's rejection, SPEEA petitioned the National Labor Relations Board to declare the action an unfair labor practice. In the meantime, SPEEA has a novel way of handling the controversial 3% that will be appearing in its members' paychecks. Engineers can volunteer to have the extra money deposited in a special bank account from which the funds cannot be withdrawn until negotiations with the company are concluded satisfactorily. Voluntary refusal of the extra money, SPEEA contends, will dramatize the widespread support of the union's position.

Can high-quality titanium dioxide be made via a continuous process?

A small firm headquartered in Montreal, Que., claims to have achieved a goal that has eluded U. S. chemical companies for years: continuous production of pigment-grade TiO_2. Continental Titanium Corp. says it is building a $2-million, 10-ton/day TiO_2 plant, using a secret continuous process, in the Baie St. Paul area of Quebec. Plant is slated to go on stream in summer of 1961.

Company's vice president and process developer, Nicholas Soloducha, says that the patented route will produce TiO_2 for 30% less than conventional batch systems. Although he will give out no details, process is believed to involve two steps: continuous leaching of ilmenite to produce a low-iron TiO_2 followed by a continuous purification to refine the product to pigment quality.

Many schemes have been advanced in the past for continuous ilmenite leaching, but all have been plagued by mechanical problems and none have been able to produce a pigment-grade product. One such process described in the literature employed a screw conveyor into which oleum and ilmenite fed continuously. Heat of reaction between acid and the ore dried the reaction mass before it reached the end of the conveyor. Discharged cake was then leached with water or dilute sulfuric acid; conversion of titanium in the ore to soluble sulfate was about 90-95%.

Interest in beryllium grows; new plant, new process announced

Following up quickly on its development of a flotation-concentration process for beryllium ores (*Chementator*, Sept. 5, p. 43) Beryllium Resources hopes to have construction under way within 9 mo. on an extraction mill near Topaz Mt., Utah.

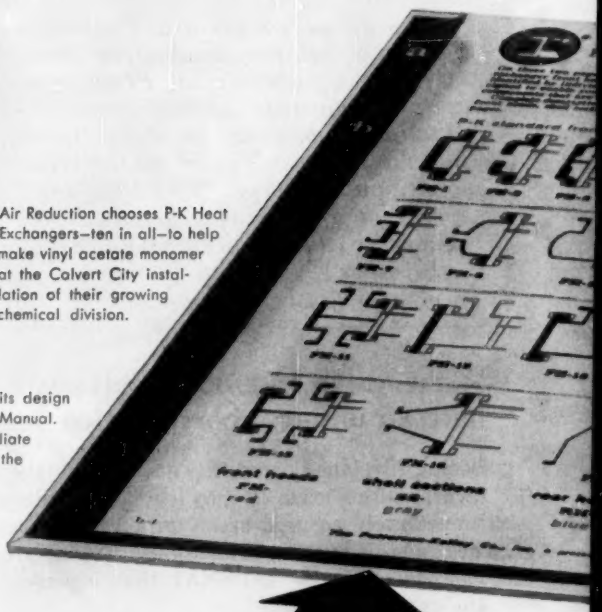
continued on page 44

NEW P-K HEAT EXCHANGER MANUAL SIMPLIFIES SELECTING COMPONENTS FOR INSTALLATIONS LIKE THIS

The P-K HEAT EXCHANGER Manual is a new 108-page work book that makes selection of a heat exchanger far easier than ever before. It enables you and your engineering staff to save time, effort and duplication of work in developing a design that will meet all your performance conditions.

This new work book standardizes terminology. It illustrates and describes components commonly used in processing. It groups interchangeable front heads, shell sections and rear heads. In much the same way, it groups standard gasket joints, tube pass partitions and shell baffles, thus greatly sim-

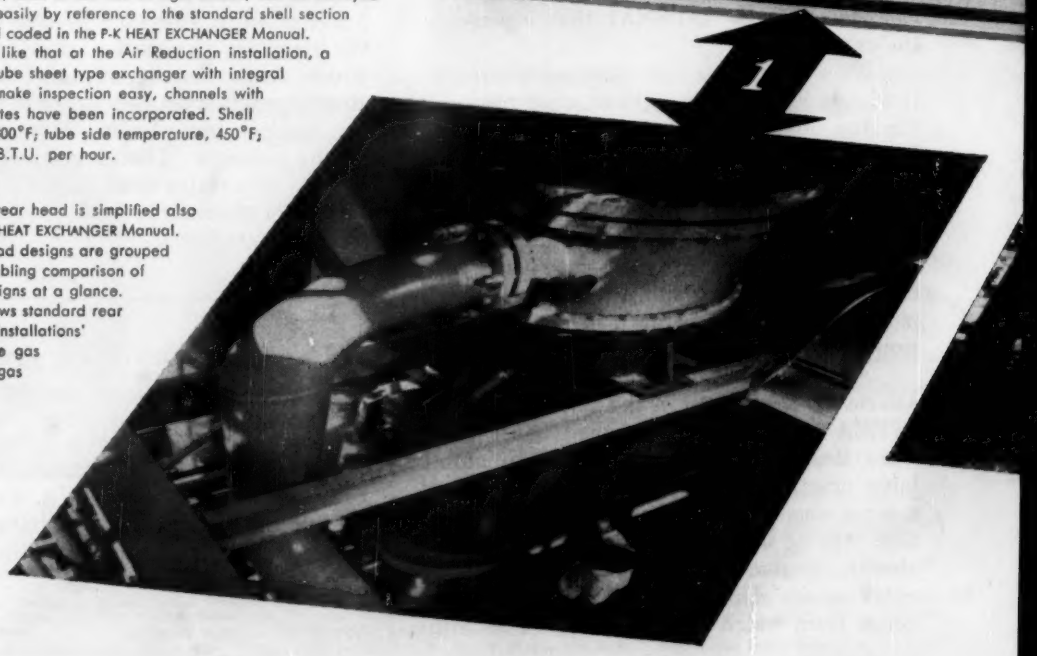
Air Reduction chooses P-K Heat Exchangers—ten in all—to help make vinyl acetate monomer at the Calvert City installation of their growing chemical division.



1 Which type front head for your heat exchanger? You can "pinpoint" its design more quickly by reference to the head coding index in the new P-K HEAT EXCHANGER Manual. In the Air Reduction installation four P-K exchangers of the type at the immediate right cool crude product gas in the tube side by means of water flow through the shell side. Tube temperature is 300°F; shell temperature 150°F; capacity, 581,000 B.T.U. per hour.

2 Shell sections, such as the one at right center, can be surveyed and specified more easily by reference to the standard shell section designs grouped and coded in the P-K HEAT EXCHANGER Manual. There are four units like that at the Air Reduction installation, a straight tube, fixed tube sheet type exchanger with integral expansion joint. To make inspection easy, channels with removable cover plates have been incorporated. Shell side temperature is 300°F; tube side temperature, 450°F; capacity is 580,000 B.T.U. per hour.

3 Selection of rear head is simplified also when you use the P-K HEAT EXCHANGER Manual. Twenty-eight rear head designs are grouped and coded here, enabling comparison of the most popular designs at a glance. Photo at far right shows standard rear head on one of the installations' two refrigerated type gas cooler and liquid-to-gas heat exchangers.



plifying the underlying details of design.

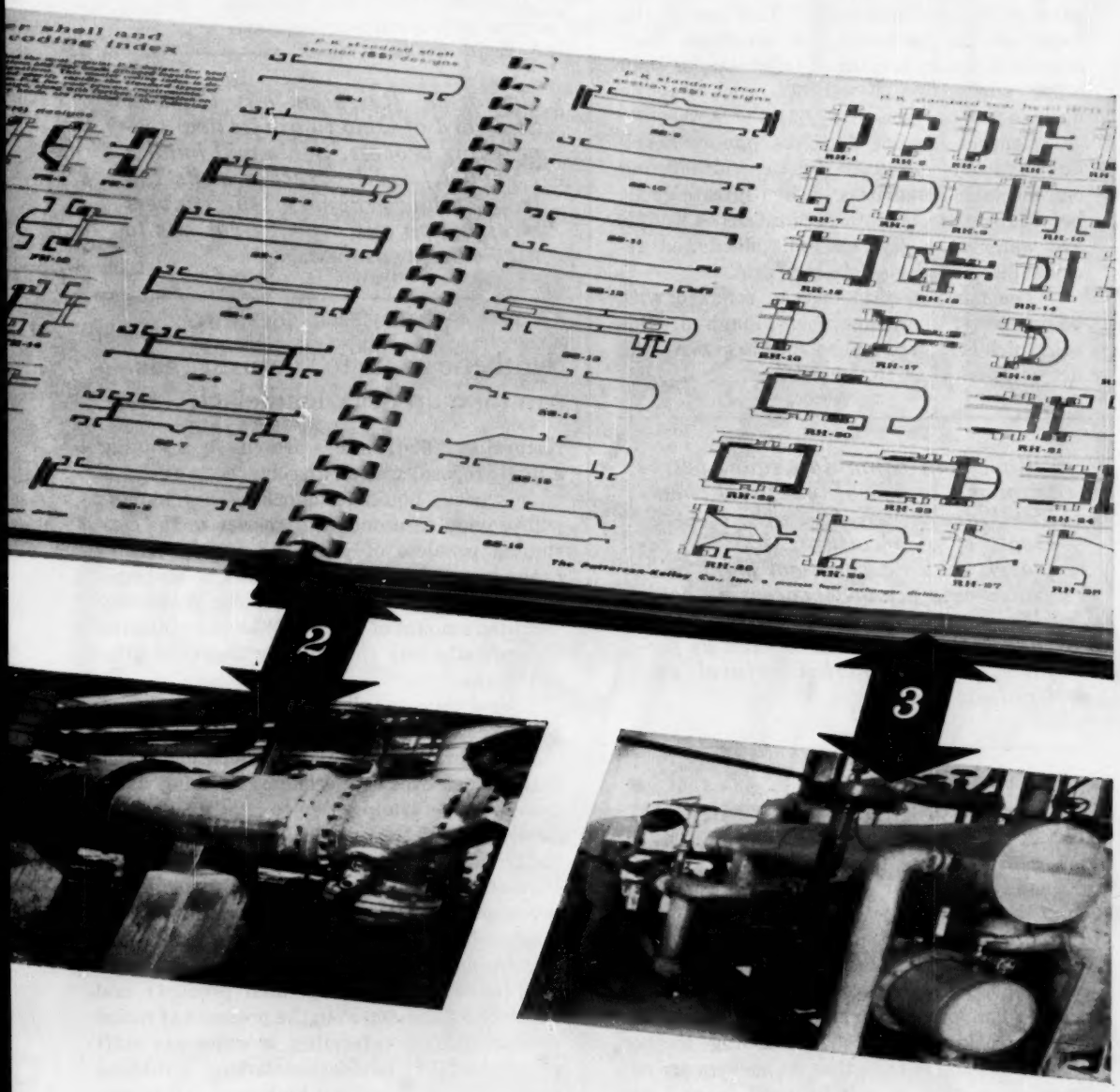
In other sections of the P-K HEAT EXCHANGER Manual you find an outline of the economic and performance advantages of principal designs, a review of the fundamentals of heat transfer, and a number of basic tables and formulas, along with a comprehensive design check list and other features.

As significant developments occur, the P-K HEAT EXCHANGER Manual will be supplemented and the new material sent to registered holders.

Available copies of this useful new manual are limited in number, and therefore are reserved primarily for those in the process industries who can best apply the information. If you design or specify heat exchangers, you are invited to write to us on your company letterhead, outlining briefly the areas of your interest. A few copies are available to students and non-technical personnel at a nominal charge. The Patterson-Kelley Co., Inc., 990 Burson Street, East Stroudsburg, Pa.

Patterson Kelley

Heat Exchanger Division



Firm says its concentration process achieves beryllium recoveries of 89-91% from ores running 0.1-3.0% BeO. Besides opening up this country's first source of beryllium, the company says it can probably sell beryllium concentrate "substantially below" the price of foreign hand-cobbed beryl of equivalent BeO content. The company has a tie-up with Brush Beryllium, so it should have no trouble finding a market for its output.

In another phase of beryllium technology, General Electric says it has found a new way to produce pure beryllium hydroxide—the gateway to beryllium metal. This new route, based on the insolubility of beryllium basic acetate in water, is claimed to be simpler than other purification flowsheets, such as the fluoride process (see pp. 81-84).

General Electric dissolves impure beryllium hydroxide in glacial acetic acid, filtering out insoluble impurities. When filtrate cools, beryllium basic acetate crystallizes. Crystals are water-washed, then redissolved and recrystallized from glacial acetic acid.

The basic acetate is then refluxed with boiling water to produce a beryllium hydroxide sol, which is filtered and washed to give a product with less than 10 ppm. silicon.

"Wood will some day equal petroleum as a source of industrial chemicals," declares E. G. Locke of U. S. Dept. of Agriculture. USDA research shows a chemical plant integrated into a wood processing complex can economically produce chemical intermediates such as furfural, hydroxymethyl-furfural and levulinic acid.

A new revolution (not political) may be in store for sugar growers

The diffusion sugar extraction process piloted by the Hawaiian Sugar Planters Assn. (*Chementator*, Dec. 28, 1959, p. 22) has successfully completed test runs over the past growing season, handling about 23,000 tons of sugar cane. The process, which substitutes warm water soaking for usual crushing method, looked so good in tests that its backers are now predicting that it will be used in any new sugar mills that are built—although it won't replace any existing capacity.

Silver Engineering Works, Denver, Colo., which participated in the test program, has entered a firm proposal to build new diffusion plants for $200/daily ton of capacity. Cost of other auxiliary equipment will bring total investment to about $400/ton of capacity, compared with about $500/ton for conventional milling machinery. New process, once installed, also requires less manpower and utilities. The Sugar Growers Assn. will be issuing a detailed cost analysis of the process in a few weeks.

California Research has licensed Standard of Ohio to use its new Isocracking process. Sohio will build a 7,500-bbl./day Isocracker at its Toledo, Ohio, refinery to convert straight-run and cracked gas oils to high-octane gasoline.

Synthetic route to "natural" gas can take up peak-load slack

Natural gas distributors are closely studying a new proposal for making synthetic fuel gas from various liquid feedstocks. They hope it will provide an economical answer to the continuing problem of peak-load supply. Long-range transmission pipelines can't be economically sized to meet maximum demand; and only a limited amount of stored LPG can be injected without affecting the burning characteristics of the gas.

New process, piloted by the Institute of Gas Technology, Chicago, combines catalytic steam reforming and hydrogasification in one furnace, achieves heat economy by using waste heat from reforming step to heat gasification tubes. Advantages cited over present commercial process (cyclic thermal cracking, with coke burn-off between cycles) are: relatively low investment, higher conversion with less by-product handling, high-pressure product.

In operation, natural or recycled product gas (one-fifth volume of final product) and steam react at 1,800 F. in the presence of nickel catalyst. After reforming, a water-gas shift eliminates CO; monoethanolamine scrubbing removes CO_2. Resulting hydrogen and incom-

Quality *costs less* in the long run!

BJ Bilton Pumps

Quality is vital in selecting a small pump too! Without the spares, auxiliaries and regular maintenance schedules most larger installations receive, the small, general-purpose pump often operates under rugged conditions with little or no care.

Backed by Byron Jackson's reputation for quality, the close-coupled Bilton is designed for this kind of service. As a compact motor-pump unit it requires no special base plate, has no shaft alignment problems and can be mounted in any position. Available in capacities from 10 to 2,000 gpm, heads to 520 feet, motors from ⅓ to 60 hp.

Quality is the best investment in the long run!

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SUBSIDIARY OF BORG-WARNER CORPORATION
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BORG-WARNER

NEW LX BILTON MODEL brings BJ Quality to the low-cost, low capacity pump market too! Write for bulletin #3-1004.

ing feed (ranging from natural gasoline and naphtha through kerosene and No. 1 fuel oil) flow to hydrogasification tubes for reaction at 1,300 F. Final product is condensed and separated into gas and liquid fractions.

Institute of Gas Technology estimates that a plant to produce 24 million scf./day of 957-Btu. gas would cost about $3.5 million.

Optical maser may shed new light on photochemical reactions

Closely following a similar announcement by Hughes Aircraft Co. (*Chem. Eng.*, Sept. 5, p. 52), Bell Telephone Laboratories has demonstrated a working optical maser. This device enables scientists for the first time to generate specific electromagnetic frequencies in the visible spectrum.

Although Bell is intrigued mainly by the communications potential of the optical maser, it also may be used in photochemical reactions. The single frequency light beam (4.2×10^{14} cycles in the case of Bell's ruby maser) could be used to excite specific chemical isomers, introducing a new degree of selectivity to photochemical synthesis. Masers employing different crystals could produce any other frequency of light desired.

Bell's maser consists of a synthetic ruby crystal surrounded by a xenon-arc "light pump." Light from the arc excites chromium atoms in the ruby to emit light of a specific frequency. Geometry of the crystal causes these waves to be reinforced, so that a concentrated beam of practically parallel rays leaves the end of the crystal. Bell has sent signals 23-mi. with its experimental model and much greater distances are possible because of the highly directional nature of the beam.

Process upgrades phosphorus-furnace slag, wins rare metal

Next summer, a new plant will come on stream in Salt Lake City that will open up an entirely new domestic source of vanadium—and provide an economic outlet for some of the slag from western phosphorus furnaces. Jointly owned by Minerals Engineering Co. and Susquehanna-Western, new facility will utilize a process developed by Minerals Engineering to treat slag from Food Machinery's Pocatello, Idaho, phosphorus plant.

Although vanadium has been in long supply, backers of the new venture say growing markets, both in ferrovanadium for steel alloying and vanadium tubing for nuclear applications, assure sales of around $2 million yearly, mainly overseas. New process will be "competitive" with conventional routes, but its main virtue lies not in cost-cutting, but in providing a new source of the silvery metal.

Details of the new process are not available because of pending patents, but here is an outline of the basic steps: tapping phosphorus furnaces periodically nets a ferrophosphorus slag containing 3-5% V. This material will be processed right at FMC's plant, in a unit resembling a Bessemer converter, yielding refined ferrophosphorus and a slag containing 12-14% V.

Vanadium concentrate will then be shipped to the Salt Lake City facility where it will be roasted with sodium chloride to form the water-soluble vanadate. After leaching with water, vanadate solution will be purified by solvent extraction. Vanadium values are then precipitated and fired to vanadium pentoxide, which will be sold as product.

Research and development briefs

Custom-tailored rubber can be produced by irradiating natural latex, report Goodyear Tire & Rubber researchers. By varying radiation dose, molecular structure can be varied at will, increasing modulus of elasticity and tensile strength as molecular crosslinking increases. Results to date indicate that commercial irradiation facilities located right on latex plantations would be economically feasible.

Plastic radiation barriers, based on liquid polyethylene resin (*Chementator*, Sept. 5, p. 43) incorporating boron or lead, have been developed by Delka Research Corp., Hawthorne, N. J. Fast neutrons are slowed by elastic collisions with hydrogen atoms in the plastic molecules, are then captured by a boron nucleus in the resin. And plastic foams incorporating lead are claimed to be more effective than concrete or water in stopping neutrons and gamma radiation.

For More Industry News . . . 48

. . . for interest in these 12 interesting new compounds from B&A®

Sulfur Tetrafluoride-Boron Fluoride Complex. ($SF_4 \cdot BF_3$)
N, N-Dimethyl Sulfamyl Chloride. [$(CH_3)_2NSO_2Cl$]
Sodium-2-Chloroethane Sulfonate. ($ClCH_2CH_2SO_3Na$)
Hydroxylamine-O-Sulfonic Acid. (H_2NOSO_3H)
Duroyl Propionic Acid. ($C_{10}H_{13}COCH_2CH_2COOH$)
2, 2-Dichlorobicyclo- (4,1,0) Heptane. ($C_7H_{10}Cl_2$)
2-Methylmercaptophenol. ($CH_3SC_6H_4OH$)
4-Methylmercaptophenol. ($CH_3SC_6H_4OH$)
Sulfamide. ($NH_2SO_2NH_2$)
Sulfuryl Fluoride. (SO_2F_2)
Sulfur Trioxide-Pyridine Complex. ($SO_3 \cdot$ Pyridine)
Methylene Sulfate. $(CH_2SO_4)_2$

Frankly, as yet we know very little about the uses for these new chemicals. We do have limited technical data on each which we'll be glad to send you. We can also provide small laboratory quantities of most of them for your investigation.

All of these new compounds have been prepared on a laboratory scale as a direct result of General Chemical's broad research programs. They are not now available in commercial quantities, but we could supply such quantities if enough demand develops.

Would you like to join our "fishing expedition"? If so, just attach the coupon to your card or company letterhead.

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COMPUTER CONTROLS CRUDE DISTILLATION...
...BIGGEST POTASH MINE...
...PRIVATE FIRMS TO GET INTO HELIUM

Test drillings proved the size of the rich Cane Creek potash deposit.

Biggest Potash Mine Shaping Up in Utah

After a winning fight with western oil producers over mineral rights to federal lands in the Cane Creek, Utah, area (*Chementator*, Oct. 3, p. 33) Texas Gulf Sulphur announces it is planning to build a $20-30-million potash plant—pending final approval by the company's directors.

TGS believes the potash deposits are richer than any other known to exist in the U. S. Plans call for an initial 2,700-ft. mine shaft that will feed about 10,000 tons/day of potash ore to a nearby extraction plant. Richness of the Cane Creek ore, says TGS, will make the plant the biggest potash producer in the country.

Crude Distillation Unit Under Computer Control

Climaxing a two-year development program by Standard Oil (Ind.) and International Business Machines, a 140,000-bbl./day crude oil distillation unit is now under open-loop computer control at Standard's Whiting, Ind., refinery. Picked for the job was a regular IBM 704 digital computer (although industry observers believe IBM is readying a new digital model tailored specifically for process control assignments).

Standard says it expects a "satisfactory" payout from the expensive computer-control hardware. But it is quick to add that it is looking "more toward the long-range impact that development work will have on refinery operations." Plans are already in the works for putting an Ultraformer under computer control. Other likely candidates: catalytic cracking and alkylation.

First phase of the control operation is the collecting of readings from 196 instruments every seven minutes. These data are transmitted over a mile-long telephone line to the administration building where the computer is housed. Every hour, the linear-programmed computer goes through an optimizing routine; more than 20,000 instructions are stored in the memory. Every 20 minutes, the computer examines the input data to determine how closely the crude unit is approaching the hourly optimization goals.

Results from all computations are sent back to the control room where they print out, so operators can manually adjust the 19 key variables. Standard says it will be a relatively simple matter to switch over to closed-loop control later so that the computer can change all the set-points automatically.

Way Paved for Firms to Enter Helium Business

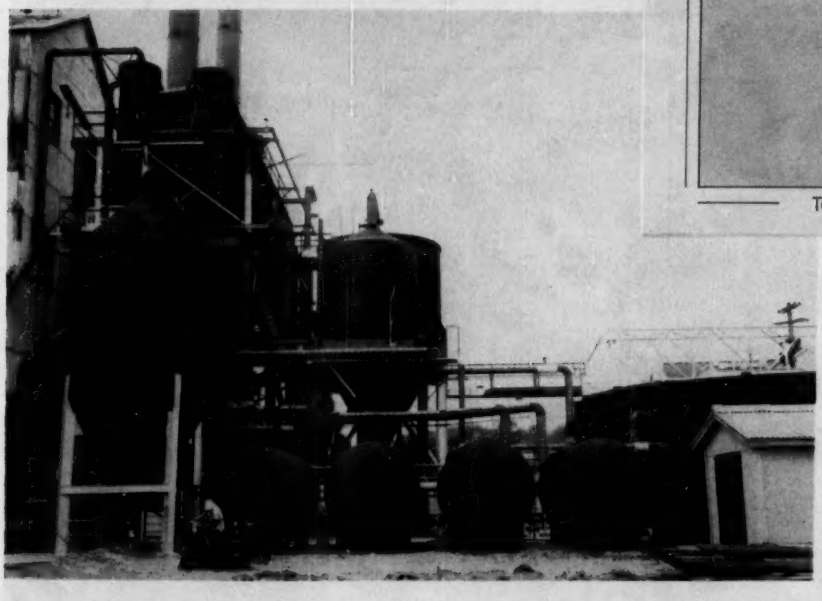
New legislation signed by President Eisenhower on Sept. 13 has made possible the helium conservation program that the Dept. of the Interior has been anxious to inaugurate.

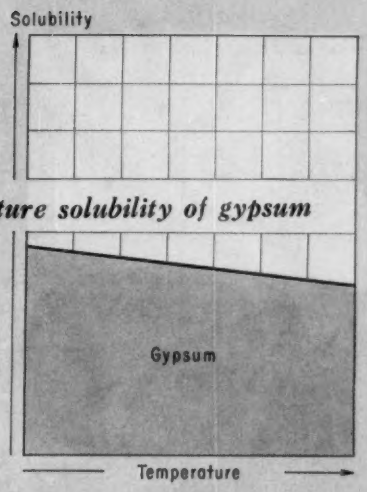
The legislation, which goes into effect next March, authorizes the Secretary of the Interior to buy helium from private industry under long-term contracts. In the overall program envisioned by Interior, private firms in the natural gas business will extract a crude (50-80%) helium stream from natural gas wells, then sell it to the government. Government will store the crude helium in its Cliffside gas field near Amarillo, Tex., will refine and sell it to meet demand.

Purchase price for the crude material is to be negotiated on a plant-to-plant basis. Interior says it will buy a maximum of 4 billion cu. ft./yr. helium, spend a maximum of about $60 million/yr. Sale price for the purified product may be pegged at $40/1,000 cu. ft.

Many helium-bearing natural gas wells are located in the Panhandle and Hugoton fields of Texas, Oklahoma and Kansas, and this will probably be where private firms will build their extraction plants. Interior reports that nearly every company controlling natural gas in the two fields is interested in participating.

Continuous purification technique makes use of inverse temperature solubility of gypsum to produce 99.99%-pure NaCl from rock salt.





First commercial installation has double-effect evaporator. Saturator (left foreground) insures maximum concentration of salt in the brine, sand filters (center) clarify it.

NEW PROCESS AUTOMATES SALT REFINING

Now on stream at International Salt Co's. Avery Island, La., mine, is the first full-scale plant employing the company's revolutionary Recrystallizer process.

With its double-effect evaporator, the plant is turning out a finished salt that assays a striking 99.99% NaCl at a 15-ton/hr. clip.

The process, which was extensively piloted at the company's Watkins Glen, N. Y., refinery, makes use of the inverse temperature solubility curve of $CaSO_4$, rather than chemical treatment, to produce high-purity salt directly from low-grade rock salt (*Chem. Eng.*, March 1952, p. 140).

But instead of the gypsum being precipitated out by heating of brine, the $CaSO_4$ in the crude salt fed to the system remains undissolved and is removed by settling and filtration.

The process is ideally suited to rock-salt mining operations where tailings from the screening step can be used as raw material. Other forms of relatively impure NaCl, such as solar salt and refuse salt, can also be refined by this means. It is not applicable where brine is the only raw material available.

▶**Internal Heaters Out**—Conventional saltmaking operations use multiple-effect calandria-type vacuum pans, or multiple-effect crystallizers with forced circulation through outside closed heaters.

International's new technique—

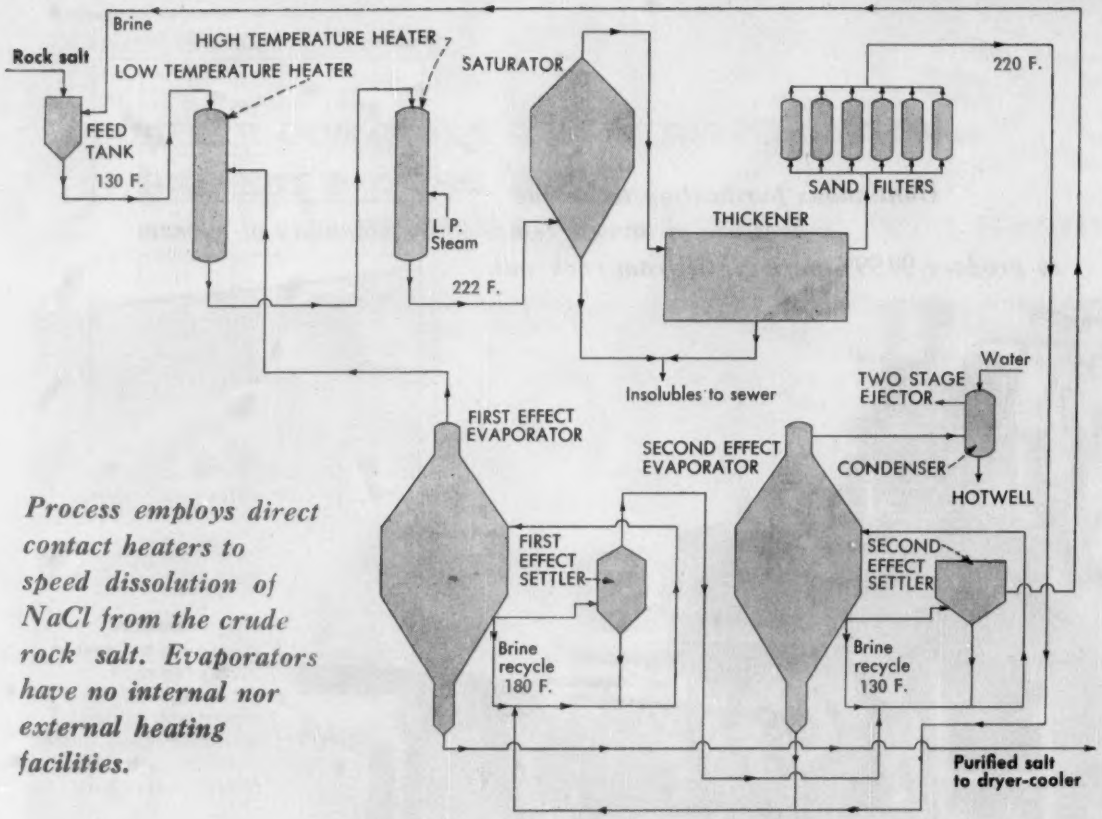
- Does not employ tubular heaters. This reduces initial investment, cuts maintenance costs, eliminates scaling.
- Makes chemical treating of brine unnecessary.

▶**Starts With Rock Salt**—At Avery Island, rock-salt fines are fed at a controlled rate into a slurrying tank (flowsheet, page 50) where they are mixed with mother liquor from, and at the temperature of, the second-effect evaporator, usually about 130 F.

Resulting slurry is pumped through a countercurrent, direct-contact heater in which vapor from the first-effect evaporator is condensed, thereby dissolving about half of the salt. Slurry is then fed to another direct-contact unit where it is heated to 222 F. by injection of exhaust steam from a turbogenerator. In areas where cooling water or steam costs are high, vapor recompression will provide a more economical source of heat for this unit.

The brine then flows upward through a saturator, where complete dissolution of the salt takes place and where a portion of the anhydride ($CaSO_4$) separates out. It is clarified by settling thickener and six pressure-type filters charged with anthrafilt.

▶**Efficient Evaporation**—The com-



Process employs direct contact heaters to speed dissolution of NaCl from the crude rock salt. Evaporators have no internal nor external heating facilities.

pletely clarified effluent (at 220 F.) discharges to the first-effect evaporator, which operates at 14 in. Hg abs. Here it flash-cools to approximately 180 F., releasing vapor that is condensed in the previously mentioned first direct-contact heater. Concentration of the brine, plus the reduction in temperature from 220 to 180 F., causes some of the salt to crystallize.

A portion of the first-effect magma is thickened in a settler, and the clarified mother liquor that overflows is fed to the second-effect evaporator. Here, it flash-cools to 130 F., resulting in the crystallization of additional salt. A portion of the slurry from this effect goes to the second-effect settler, and the clarified mother liquor that overflows is pumped back to the feed tank for slurrying more rock salt.

Salt crystallized in both evaporators settles into elutriating legs against a classifying current of brine. This salt is withdrawn periodically and pumped to a top-feed, rotary filter-dryer, where gas-heated air completely dries the crystals. Filtrate is returned to the main system. The hot salt at 210 F. is discharged into a rotary cooler and cooled to 150 F., then is conveyed to screens and storage or directly to loading.

Since $CaSO_4$, the chief impurity in rock salt, is extremely insoluble at 220 F., the brine fed to the first-effect evaporator is very pure. Cooling action in the evaporators causes the mother liquor to be undersaturated with respect to $CaSO_4$ and, therefore, no crystallizing out occurs in the evaporating process. The result is a salt as pure as it is possible to make commercially.

▶**Economy of Operation**—Steam consumption per ton of salt produced in the double-effect unit at Avery Island is comparable to quadruple-effect economy in calandria or forced-circulation evaporators.

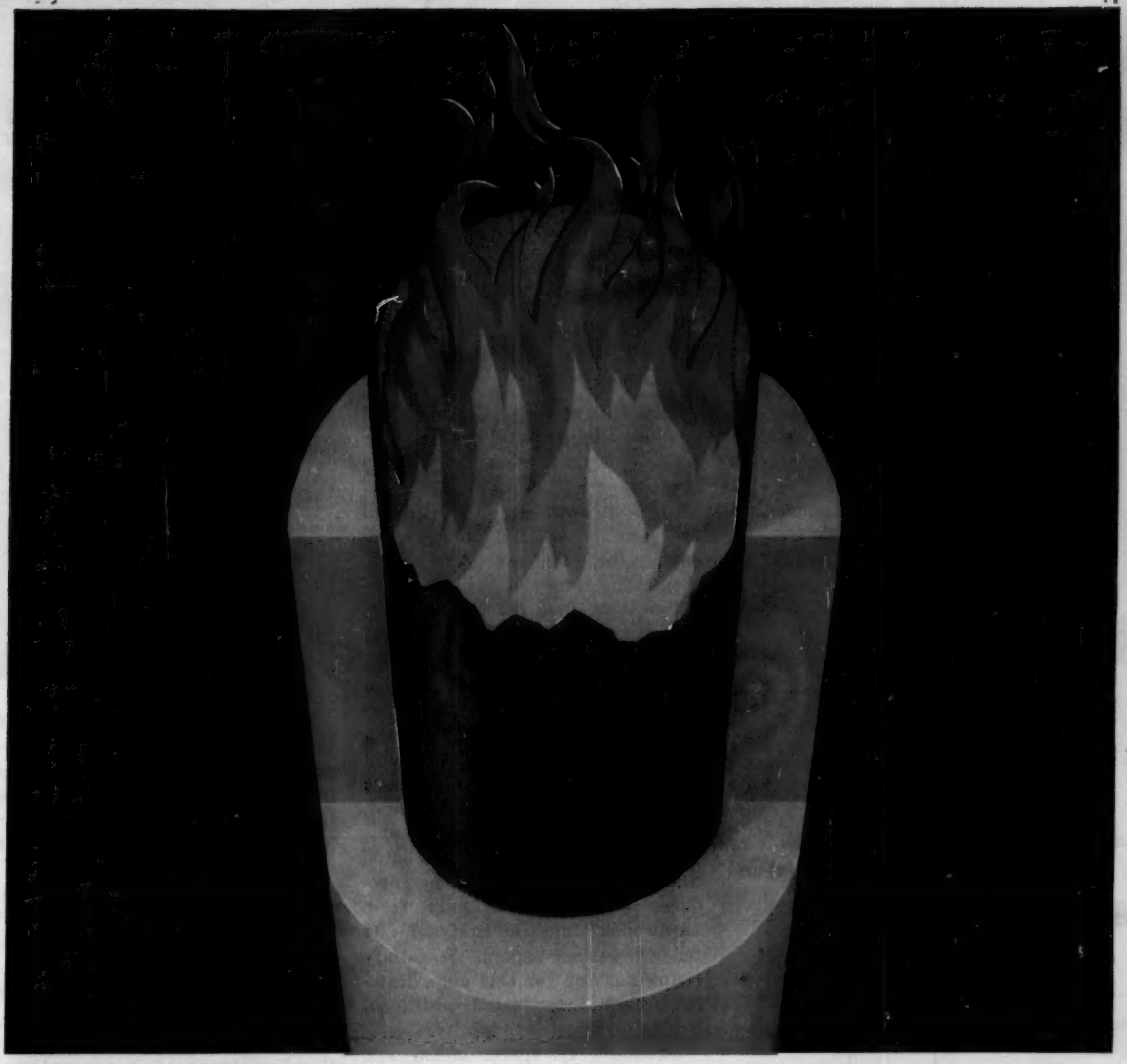
An additional saving is the elimination of the expensive lime and soda ash treatment that is required to produce a salt of comparable purity in conventional systems. Also, the initial cost of a double-effect Recrystallizer is somewhat less than a quadruple-effect forced-circulation evaporator, due principally to the elimination of two evaporators.

Furthermore, the absence of tubular heat exchangers reduces maintenance.

Since there is no condensate return, however, cost of boiler feedwater is higher than normal.

Use of Monel evaporators and 316 SS pumps was considered essential at Avery. However, the brine purification vessels were constructed of steel and are being protected from corrosion by cathodic means. All piping beyond the filters is nonferrous to preclude contamination from iron particles.

▶**Instrumentation Essential**—Levels of the liquid in all atmospheric and vacuum vessels are automatically controlled. Magnetic flowmeters are used to measure the flow of hot brine through each filter, and a remotely controlled gravimetric feeder measures rock salt into the slurrying tank. Also under automatic control is the temperature of air fed to the salt dryer, and the exhaust steam fed to high-temperature heater.—AVG



1800° IS NOT TOO HOT FOR NEW CALSILITE-HI

New Ruberoid Calsilite-Hi insulation for soaking heat to 1800°F. It's light, strong and so economical it can be used on all types of jobs. Calsilite-Hi is ideal for both insulation and fireproofing.

Calsilite-Hi, a molded calcium silicate insulation, extends the Ruberoid insulation line to the upper temperature limit of 1800°F. Available in half-sectional, three segmental and block form, it can be used as fireproofing for walls, partitions and ceilings as well as insulation for piping and equipment.

Calsilite-Hi is light and easy to install. It cuts and mitres quickly, smoothly and is gentle on hands. What's more, it keeps its strength even when wet, does not soften or fall off. Returns to its original thermal efficiency when dry. Resists most chemicals and alkalis in industrial concentrations.

For additional specifications or samples of Calsilite and Calsilite-Hi insulation, write: The Ruberoid Company, 500 Fifth Avenue, New York 36, New York.

THERMAL CONDUCTIVITY
(BTU/sq. ft./inch/hr./°F.)

400°F. (Mean).....0.54
600°F. (Mean).....0.64
800°F. (Mean).....0.74

Density 13.5 lbs. per cu. ft.

Compressive Strength
5% deformation (Min.) 135 lbs. psi.

Flexural Strength 75 lbs. per sq. in.

Change under Soaking Heat
24 hrs. @ 1800°F.
Loss in weight.....5%
Linear Shrinkage.....1.5%

The RUBEROID Co.®

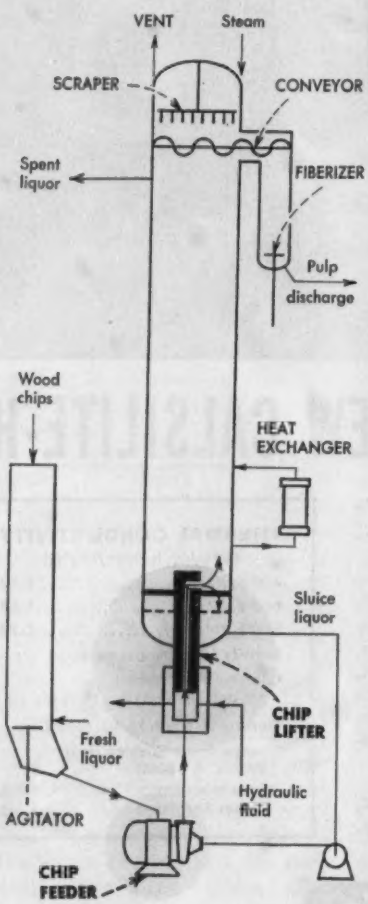
POTENTIAL UNFOLDS FOR UPFLOW PULPING

First continuous vertical upflow digester enters second year on stream with output approaching 130% of design capacity and a 200% goal in sight.

The period of "wait and see" has ended for Hammermill Paper Co.'s unique continuous pulping process at Erie, Pa.

Royal H. Raasch of Hammermill confirmed this at the 14th Alkaline Pulping Conference of TAPPI* in Portland, Ore., by stating that the process already has produced at 128% design capacity, seems headed for 200% output before it levels off. Furthermore, quality is the same as batch pulp produced during the identical 1-yr. period, within the limits of measurement.

* Technical Assn. of the Pulp & Paper Industry



►Two-Way Deal—Does this performance stem from the uniqueness of the process? To a large extent, yes. And, in turn, the unusual process results from the happy combination of Hammermill's recently developed Neutracel hardwood pulping technique with Improved Machinery, Inc.'s, completely new, continuous upflow pulping tower.

First used in 1952 on a batch basis, the Neutracel process produces neutral sulfite pulp from hardwoods, for use in bond and other fine-grade papers. To satisfy rising demand for this pulp, Hammermill had to install additional batch or continuous capacity.

Economy of space, steam and manpower, together with the hope of greater uniformity of product, favored installation of a continuous system. And the need to pulp substantial tonnages for lengthy reaction periods at moderate temperatures (with the chips fully submerged) pointed toward use of a large vertical upflow digester.

The only hitch: up to that time, no one had been able to build this type of commercial digester able to move chips upward without damage.

►Hydraulic Lifter Turns the Trick—Impco resolved this problem by designing a hydraulically operated lifter to propel the chips up the tower. The working element, or platform, is a perforated single-turn helical screw piston, positioned to move up and down in the bottom of the tower.

Chips are sluiced onto the top of the piston by a positive displacement feeder and pump having intermeshing twin screws. Because the piston is perforated, liquor in the tower moves independent of the column of chips.

Spent liquor discharges from the top of the tower below the level where the conveyor removes the cooked chips. Not only is heat recovered but, also, the organic solids in the liquor are equivalent to the quantity that would be removed by the first stage of a conventional three-stage countercurrent pulp washer.

►Tops Performance Quota—Some advantages that are inherent in the operating principles are pushing Hammermill's output far beyond design capacity:

With upflow design, chips are subjected to maximum hydrostatic pressure as soon as they enter the bottom of the tower. This forces the liquor into them in minimum time. Heating of the chips to reaction temperature is rapid, as liquor is withdrawn near the bottom of tower, heated by exchange with liquor and steam, then returned higher up.

Uniform density is maintained in the packed chips by random rotation of the lifter after each upward stroke. Upflow of chips, feed rate

These are the key units

Chip lifter is a large perforated piston that periodically elevates entire mass of chips while permitting liquor to flow through the perforations.

Chip feeder is positive displacement unit that gives nonplugging operation at very high wood-to-liquor ratios.

Continental-Emsco

SWIVEL JOINTS..

modern joints you can

WELD

into the line!

Now you can say..

goodbye to leaky threads C-E joints welded into loading arms eliminate excessive maintenance costs caused by dripping caustic fluids.

goodbye to costly flanges C-E weldable joints eliminate need for flanged connections when fabricating loading arms.

goodbye to higher installation costs C-E weldable joints are easier and faster to install, lower priced and stronger, too.

goodbye to time-consuming packing replacement C-E weldable joints can be repacked when necessary without removal from loading arms.

Continental-Emsco's patented design permits bearings to remain in place *even during* packing replacement or adjustment. Simply loosen set screws and turn body. Joints break like a union, exposing *only* the packing.. bearings are *never* disturbed. Wide spacing of high capacity bearings.. another exclusive C-E feature.. permits greater foot-pound loading on the joint. Additional features include on-location replacement of worn parts.. elimination of split bearing races for added strength.. reversible races on most joints for double service life.

Write today for our new catalog on C-E's modern line of swivel joints.

C-E joints are manufactured for practically all petrochemical and chemical services. Sizes are available from 3/8" to 12" diameter in steel.. from 2" to 12" diameter in aluminum. Joints are also available in threaded or flanged styles for replacement in existing systems.

SJ002

CONTINENTAL-EMSCO COMPANY
A Division of The Youngstown Sheet and Tube Company

Industrial Products Division
P. O. Box 359,
Dallas 21, Texas

of fresh pulping liquor, and temperature, can be adjusted to produce the desired degree of cooking. Reaction rate can be doubled for each temperature rise of 7 deg. C.

Under the old batch conditions, pressure is limited to 110 psi. And the cook takes about 3½ hr. to complete the required temperature rise.

The new digestion system was designed for 125-ton/day moisture-free bleached pulp, operating with a 2½-hr. cook. But with a 250-psi. rating, there is latitude to exploit conditions that will shorten pulping time and increase capacity.

At a 160-ton/day rate, pulp quality is equivalent to that produced by the batch method during the same period under the much longer cooking cycle.

Using a new laboratory digester, Hammermill has studied the process in the high rate range corresponding to 250 ton/day. While the results indicate some decrease in yield, the company eventually expects to operate the digester at this rate.—CSC

Fuel-Cell Developments Maintain Rapid Pace

A long-term research program, underwritten by 25 companies to advance fuel-cell technology, has just begun at Battelle Memorial Institute, Columbus, Ohio. Tentatively scheduled for five years, program will be fundamental in nature, is designed to complement existing government, industrial and academic fuel-cell research.

This program is the first step taken by private industry to bring order and perspective to this fertile research field. According to Battelle's project director, John McCallum: "Before the fuel cell's potential can be realized as a power source for automobiles, domestic heating and cooling, and industrial processes, there will have to be a number of innovations."

Besides collecting and evaluating new fuel-cell data from all sources, Battelle will conduct original research in the area of fuel-cell materials. One aim will be to develop an alloy with unique electrical properties; other studies will examine the special properties of thin-metal films and metal-chelate-coated carbon electrodes.

Emphasizing the interest that a growing number of companies have in fuel cells, three firms made recent announcements: Ionics, Inc., Cambridge, Mass., has developed a lightweight hydrogen-oxygen cell with plastic ion-exchange membrane for power generation in earth satellites. Cell is reversible, can utilize electric current from solar cells to break down water into H_2 and O_2 while the satellite is in the sun, then recombine the gases to form water and electric current when the satellite passes through the earth's shadow. It is similar in principle to General Electric's ion-exchange cell (*Chem. Eng.*, May 30, p. 50).

And Standard Oil (Ind.) and McGraw-Edison are combining forces for joint fuel-cell research. Object of the work will be to find a cell that can run on hydrocarbons. Ultimate aim is to replace the gasoline engine with a device taking advantage of the fuel cell's high (60-75%) fuel efficiency.

Vinyl shield blocks seepage through tank foundations

Engineers, above, are shown installing what is believed to be a novel advance in concrete tank construction. After a 2-in.-thick foundation slab of concrete has been poured and dried, a single piece of vinyl plastic sheet is laid on top of it. A 4-in. slab of reinforced concrete is poured on top of that, sandwiching the plastic and forming an impenetrable water barrier. Vessel under construction is a 560,000-gal. water tank, being erected in La Verne, Calif. Bottom slab is 72 ft. in dia., sides will be 23 ft. high when tank is completed.

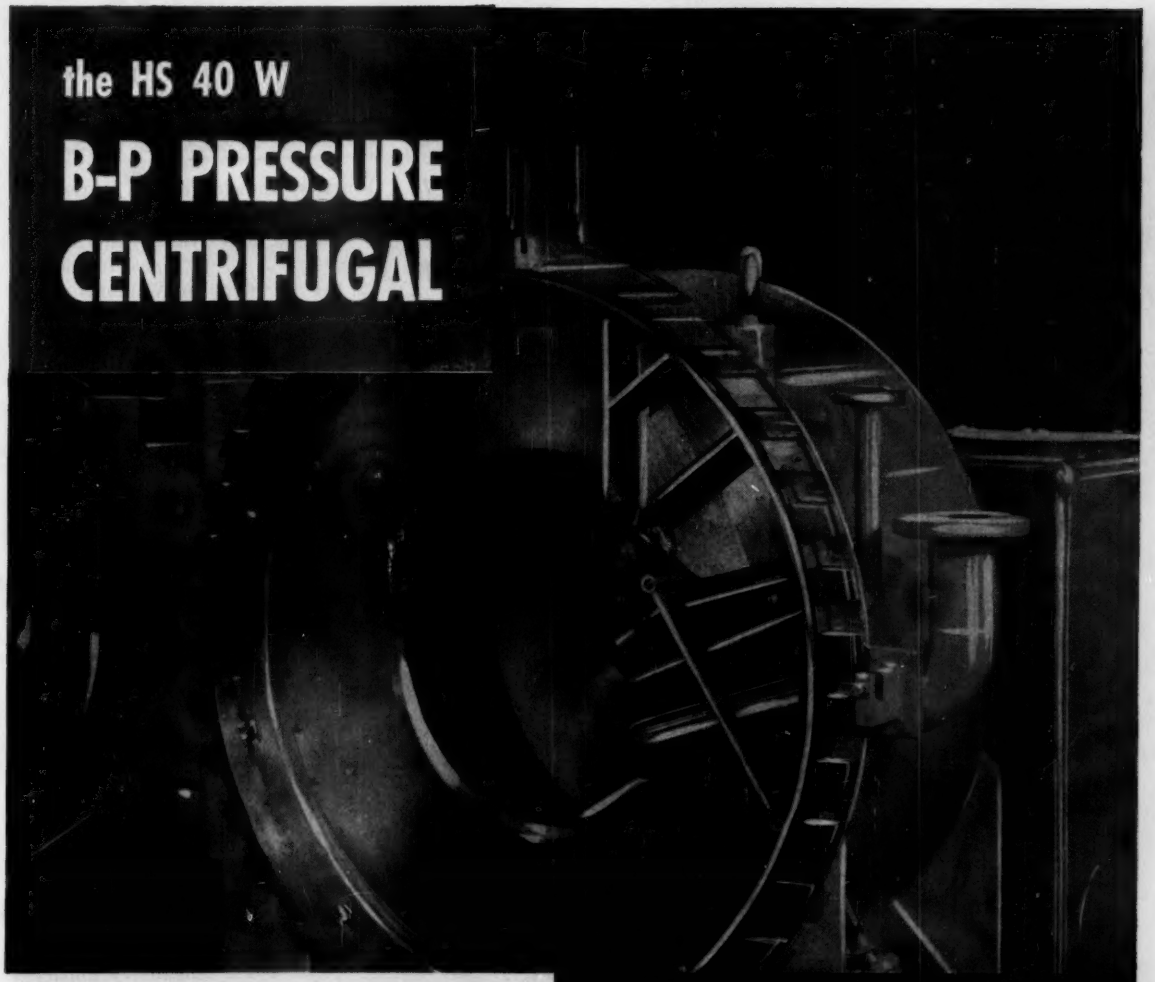
Now, Tougher Steels For Process Equipment

One of the steel industry's answers to the threat of high-performance, but expensive, exotic alloys are new high-performance steels that cost less than the rarer metals. First in this line of new-generation materials is a grade of supertough steel, originally designed for armor plate but now available in sheet and strip.

Ability to roll this steel into sheet makes possible a whole family of high-strength, low-weight industrial equipment, according to U. S. Steel, which is turning out the material at its Homestead, Pa., rolling facility. Products of interest to the chemical industry that can be fabricated from the steels include equipment for handling liquefied gases such as oxygen and nitrogen.

the HS 40 W

B-P PRESSURE CENTRIFUGAL



BAKER PERKINS research now brings you the HS 40 W Universal Pressure Centrifugal, engineered for normal operation at 1000 times gravity and internal pressures to 150 psi. Several important features are entirely new: A MECHANICAL SELF-BALANCING SHAFT SEAL is positioned where the main shaft enters the housing and is the only major moving seal. A CLAMPING AND SELF-ALIGNING DOOR SEAL consisting of a floating ring plus two O-rings assures a completely safe lock without the necessity of tightening bolts. A SIMPLIFIED DESIGN OF THE DISCHARGE KNIFE AND CHUTE. Complete discharge of all solids is effected, eliminating swirling or dusting of solids within the housing. PROGRESSIVE PEELING. For the first time, provision is made for the peeler knife to enter the cake at successively increasing depths. Glazing of the heel is eliminated. Air displacement is controlled during both the charging and peeling operations.

As in all Baker Perkins Universal Centrifugals, the interior of the new model is completely and readily accessible. For complete specifications of the high capacity HS 40 W Universal Pressure Centrifugal, see your B-P sales representative or write to:

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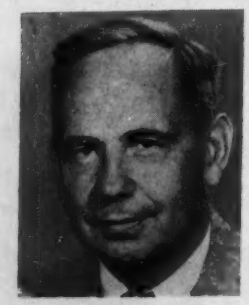
394

EXPERTS CUE Ch.E's TO WHAT'S NEW

• *Conference on The New Chemical Engineering will draw 300 registrants to Kansas City on Nov. 29 and 30.*

• *Below is a facsimile of the preregistration card. It will reserve your place among the conferees who will hear how to apply new engineering tools to their work.*



Henry Eyring, U. of Utah

T. J. Williams, Monsanto

Pictured at left are two of the authors who will deliver papers at the Conference on The New Chemical Engineering, set for Nov. 29 and 30 at Kansas City's Hotel Muehlebach. The meeting is cosponsored by Midwest Research Institute and *Chemical Engineering* (see program in *Chem. Eng.*, Oct. 3, p. 48).

Author Williams is already known to the readers of *Chemical Engineering* for his series on systems engineering. An engineering supervisor in Monsanto's research and engineering division, Williams will detail the mathematics needed for full examination of control systems, pursuing the subject farther than he has in his *CE* series.

Henry Eyring is dean of the graduate school and professor of chemistry at the U. of Utah. He is a widely known authority on rate processes and in his paper will examine the state of process kinetics knowledge and ways to move from theory to practice. Eyring is this year's Schoch lecturer at the U. of Texas, following in the footsteps of Williams who was the lecturer last year.

Other distinguished authors on the program include J. S. Dahler, professor of chemical engineering at U. of Minn. He will emphasize application of statistical mechanics and kinetic theory in solution of engineering problems. Yudell Luke's paper on numerical analysis will be especially timely because of the increasing use of computers in problem-solving. Luke heads up mathematical analysis at MRI.

T. L. Koehler of American Cyanamid is to show how statistics can increase productivity on the production line. J. C. Hetrick, operations research authority at Arthur D. Little, will explain how OR can save money in widely varying applications.

To explore solid-state phenomena from the chemical viewpoint, conferees will hear Rowland Johnson of Texas Instrument's research division. Norman Hackerman, head of U. of Texas' chemistry department, will examine those aspects of new chemical developments that are important to the process man.

CONFERENCE ON
THE NEW CHEMICAL ENGINEERING

Cosponsored by
Midwest Research Institute and Chemical Engineering Magazine
Hotel Muehlebach, Kansas City, Mo.
November 29 and 30, 1960

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Conference fee is $50. However, your advance registration, postmarked no later than November 21, entitles you to a 10% reduction in exchange for your help in anticipating accommodations required. To preregister, please fill in both parts of this card and enclose with your check for $45 payable to Midwest Research Institute and send to B. C. Shaw, Midwest Research Institute, 425 Volker Blvd., Kansas City 10, Mo.

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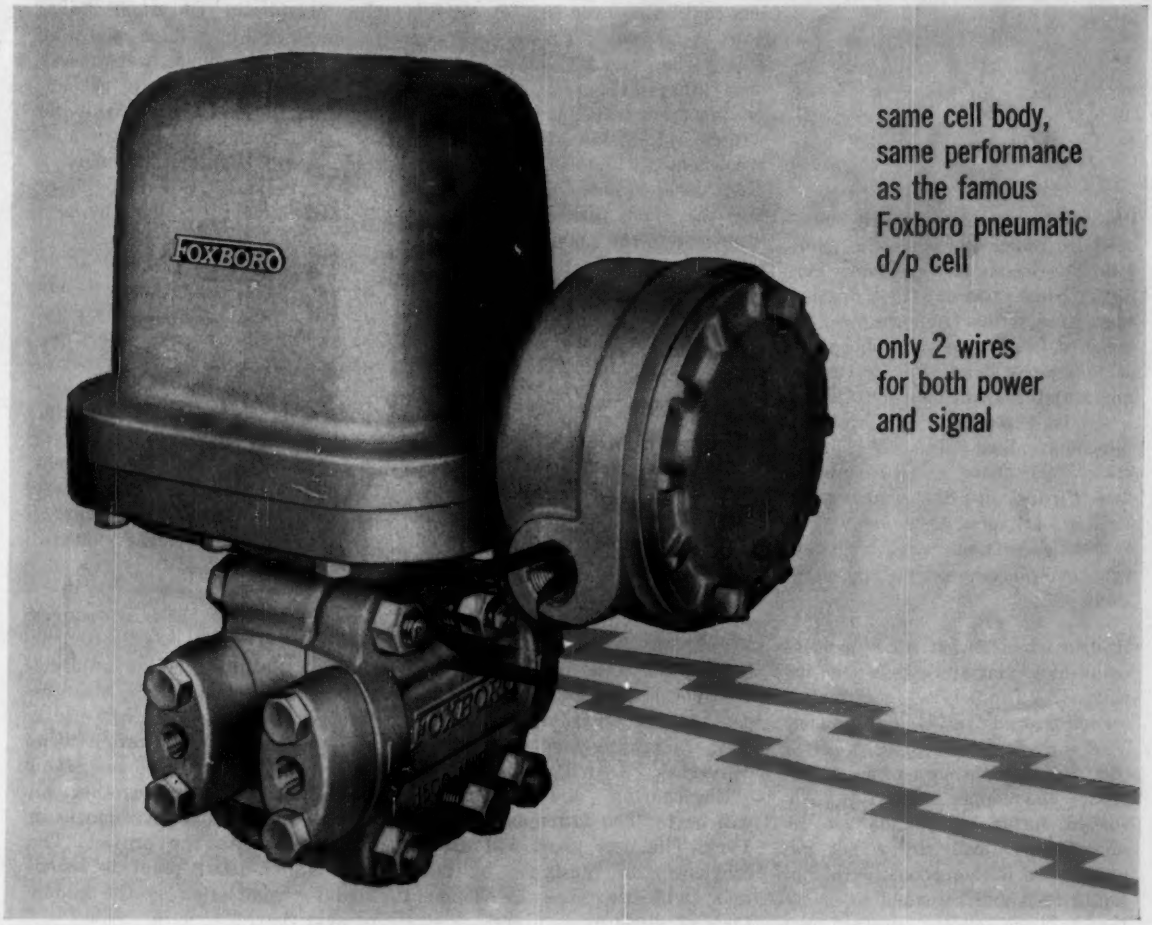

The Foxboro electronic d/p cell transmitter and this Foxboro pneumatic d/p cell transmitter use the identical cell body. Only the top transmitting mechanism has been changed.

Yes, Foxboro has taken its famous pneumatic d/p Cell and added the benefits of electronic transmission. It's the new Foxboro *electronic* d/p Cell transmitter. Look at the results:

- both power and signal travel over the same pair of unshielded wires — no field power supply required
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And, of course, you get the same positive overrange protection, the same high sustained accuracy, the same rugged construction that has always been standard with the Foxboro d/p cell transmitter.

If you're thinking "electronic," it will pay you to investigate this important instrument in the Foxboro Electronic Consotrol* family. Get in touch with your Foxboro Field Engineer for complete details, or write for Bulletin 21-10. The Foxboro Company, 3610 Neponset Avenue, Foxboro, Massachusetts.

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CPI News Briefs

- Processes
- Plants
- Offices
- Companies
- International

Processes

Phosphate-ore flotation cell developed by Smith-Douglass Co., Norfolk, Va., boasts 95% recovery (vs. 85% conventional) by floating silica impurities from the ore, instead of floating out the phosphate as is usually done. Phosphate ore and amine reagent charge to top of a special three-level cell; air bubbles float silica off while concentrated phosphate exits as underflow. Firm claims new system saves 30% in equipment costs and 20% in operating costs compared with conventional phosphate flotation operations.

Hydrocarbon sweetening process using molecular sieves has been developed by Linde Co. Liquid hydrocarbon flows down through a molecular sieve bed that adsorbs sulfur compounds, yielding a product that passes the copper strip test. Adsorbed sulfur compounds are removed periodically by a hot gas purge; bed is then cooled with sour liquid feed and returned to operation. Linde claims process has several advantages over caustic scrubbing.

Municipal water purification may be improved by using a light-scattering microphotometer. Developed by engineers at General Electric's Richland, Wash., plutonium facility, technique is being applied by city of Pasco, Wash., to regulate addition of purification chemicals. Microphotometer detects slight changes in turbidity after addition of coagulants such as alum and may cut Pasco's reagent costs by as much as 50%.

Iron ore upgrading process using Allis Chalmers' grate kilns is successfully operating at Humboldt Mining's new plant at Ishpeming, Mich. (*Chementator*, Apr. 4, p. 60). Following beneficiation of low-grade hematite and balling into pellets containing over 60% Fe, green balls feed to preheating grate where they contact high-temperature kiln exit gases. Pellets discharge from traveling grate into a 120-ft. rotary kiln for final heat treatment at 2,450 F. Result is hard dense spheres that are ready for the blast furnace. Fuel consumption in the 2,000-ton/day plant is about 1 million Btu./long ton.

Plants

SunOlin Chemical Co. is building a $20-million plant to make ethylene and ethylene oxide at Marcus Hook, Pa. The new unit will be next to Sun Oil's refinery, will go into operation late in 1961, according to present plans. Design capacities will be 225 million lb./yr. ethylene, 55 million lb./yr. ethylene oxide. Included in the over-all project is a multiple pipeline crossing that will pass under the Delaware River to New Jersey to facilitate product deliveries.

Engineering and construction will be by The Lummus Co., New York. The new plant will use an ethylene route designed by Lummus, will use Shell Development Co.'s ethylene oxide process.

Diamond Alkali Co. will build a new acetylene plant at Deer Park, Tex., which will permit the firm to expand its vinyl resin capacity at that location by 50%. Plant will make acetylene by partial oxidation, will receive oxygen and nitrogen (the latter for blanketing) from **Linde Co.**, Div. of Union Carbide Corp.

Linde will supply the gases from a plant that it will build near Diamond's site on the Houston Ship Channel. Linde will supply 320 tons/day oxygen and 105 tons/day nitrogen to Diamond but will build its plant with capacities greater than Diamond's requirements. Industry observers in Houston report that Linde will use its new facility to supply other chemical plants on the Channel as well.

Olin Mathieson Chemical Corp. will build a $1.5-million plant at Joliet, Ill., to produce wet-process phosphoric acid for use in preparing fertilizers. Capacity will be about 50,000 tons/yr. and the acid product will be in the form of a 75% concentrate. Company hopes to have the plant completed by next May.

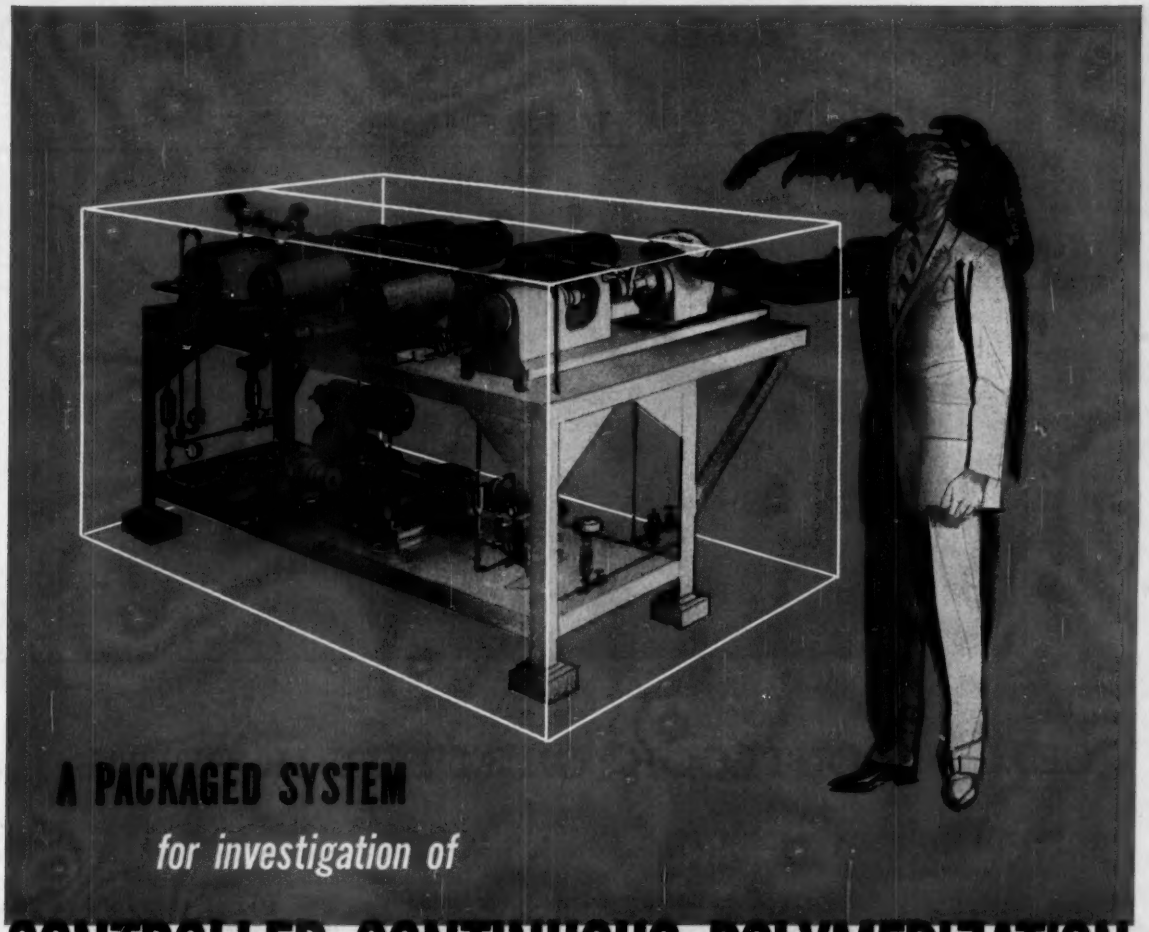
Celanese Corp. of America will buy 1,000 acres of land near Bay City, Tex., as site for eventual construction of a multimillion-dollar petrochemicals plant. Company spokesmen won't yet disclose specific details on the plant but say it will be a logical extension of current Celanese operations in Texas. These include production of oxygenated hydrocarbons and linear polyethylene.

Foster Grant Co., Inc., announces that it will erect a polyethylene plant in Beaumont, Tex., adjacent to Mobil Chemical Co.'s ethylene facility. The new unit will use a high-pressure polymerization technique, and Foster Grant and Mobil have been working together on process and product development in connection with the project. The multimillion-dollar plant is scheduled for completion by the middle of next year.

Humble Oil & Refining Co.'s Enjay Chemical Co. division announces that a new acetone unit has been completed at Humble's Bayway, N. J., refinery. Having a capacity of over 100 million lb./yr., the facility will make acetone by catalytic dehydrogenation of isopropyl alcohol.

American Cyanamid Co. is building a paper resins plant at Vancouver, Wash., to serve the area's paper industry. Occupying a 12-acre site, the facility is expected to be in operation early next year.

CPI NEWS BRIEFS
(Continued on page 144)



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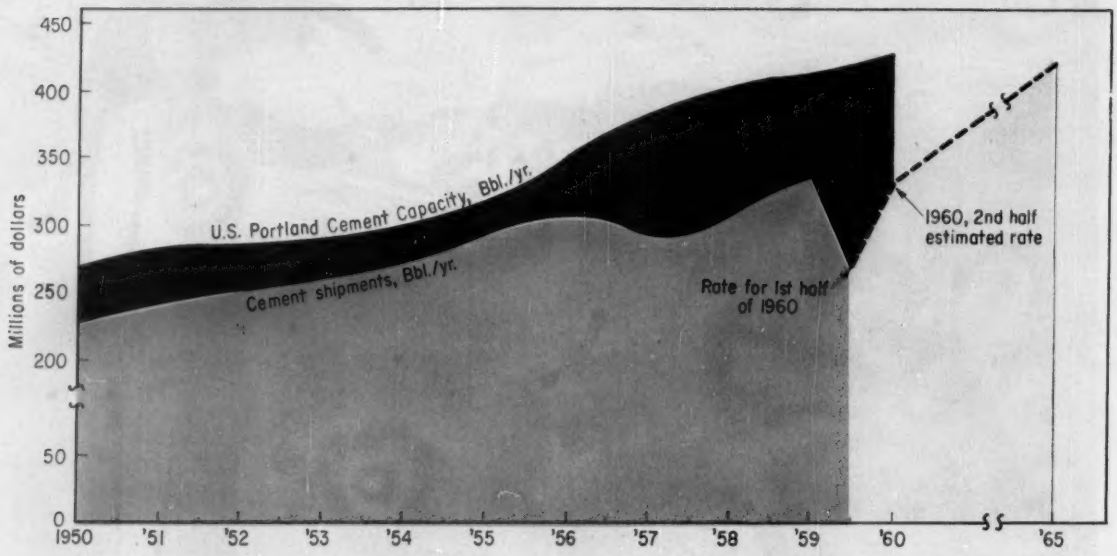


CEMENT OUTLOOK: GRIM BUT HOPEFUL

FREDERICK C. PRICE
Assistant Editor

For U.S. cement producers, 1960 is the year of "chin up, and keep a stiff upper lip." There are various reasons for this, but they have all had the same effect—to reduce the quantity of cement shipped from U.S. plants and/or to reduce the profits from shipping it.

Two major cases for the present depression in the cement industry are the slow beginning in the widely-heralded federal highway program, and even more important, the downturn in housing starts. Not as damaging, but perhaps more significant, is competition from foreign cement in both coast market areas.

While struggling to surmount these difficulties, the industry received a somewhat unexpected jolt from another direction when the Internal Revenue Code was amended to cut off the mineral depletion allowance at the point where cement makers introduced materials into the kiln.

A previous decision had permitted the allowance to be based on finished product. Since the product has a much higher value than kiln raw materials, depletion allowances for tax deductions will be smaller, profits correspondingly lower.

Despite the immediate gloomy picture, however, most producers speak hopefully of the future. They feel that the 50% expansion in plant capacity that took place during the past ten years was necessary to meet basic demand for cement in the expanding '60s, and also point to a host of new uses for their product that could increase the demand even more.

Perhaps part of their optimism stems from pronouncements from both major presidential candidates on the necessity for some degree of government help to boost the gross national product—an operation that historically has resulted in increased construction of public facilities.

1960—four factors flail sales, profits

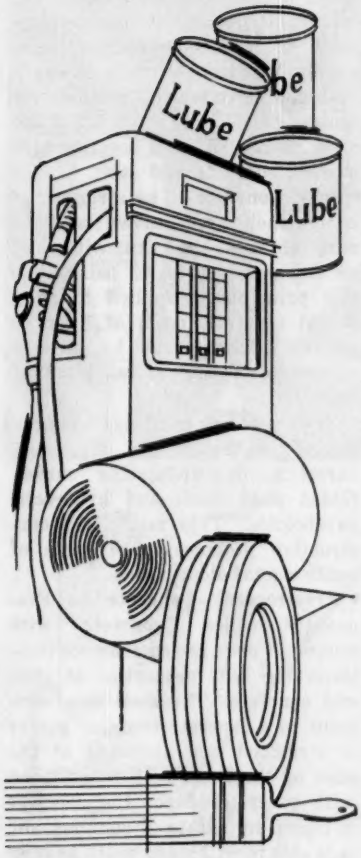
Except for a brief lull in 1957, the production of Portland cement (which comprises 95 to 98% of all cement output in the U.S.) has increased every year since 1950, through 1959. This year (particularly in the first half) the bottom fell out of the market with a resounding thud. Here are some of the reasons:

► **Highway Program** — When the plan to build 41,000 miles of interstate highways (connecting over 90% of all cities with populations of 50,000 or more) was first announced, concern was expressed that the cement industry, even with its rapid rate of expansion, would not have capacity to meet the demand.

Thus far, the program has not moved ahead at the pace originally contemplated, and even though roadbuilding is being accelerated as a result of an order from the Dept. of Commerce in June, the upswing will probably not be enough to carry cement shipments to last year's level of about 335 million bbl. (One bbl. is 376 lb.)

► **Housing and Structures** — Pri-

QO® Furfural offers Montage of uses as a selective solvent



Just as a montage is a composite illustration to an artist—QO furfural offers a composite of solvent extraction ideas for the chemical engineer. Furfural is highly polar which favors sharp separations of saturates from unsaturates in lube oils, gas oils, cycle stocks and other petroleum products as well as wood rosin, glycerides, butadiene. Supplementing the basic advantage of preferential solubility, furfural is easy to reclaim, easy to handle, and easy to buy.

Uses for which QO furfural offers advantage as a selective solvent include:

Lubes: In the furfural refining of lube stock the undesirable aromatic and olefinic components are selectively dissolved and separated from the desirable paraffins and napthenes.

Cat Cracker Cycle Stock: Furfural treatment of cycle stock sharply reduces carbon lay down on the catalyst which means improved cracker efficiency and greater gasoline out-put. Furfural reduces heavy metal contaminants, sulfur bearing materials and carbon residue.

Wood Rosin: Furfural removes color bodies from crude FF grade wood rosin to produce a light colored product equivalent to X grade.

Butadiene: In the purification of butadiene, furfural alters relative volatilities of butadiene and other C_4 hydrocarbons. This permits easy fractionation of compounds differing in degree of unsaturation to give good yields of high purity butadiene.

Glycerides: Glyceride oils may be separated by solvent extraction with furfural. Furfural selectively removes unsaturated glycerides from saturated ones.

If you have a separation problem, furfural may well be your answer. Write for information indicating nature of material to be extracted.

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vate and public housing, together with all types of structures such as bridges and public buildings, make up about 43% of the cement market.

The decline in cement shipments partly results from the slump in housing starts, which were off close to 20% during the first half of the year, compared with the 1959 level. As if this weren't bad enough, many construction projects suffered considerable delay during the first quarter because of bad weather in many parts of the country.

▶ **Foreign Competition** — Slowly but surely, foreign cement has been creeping into the market along the Eastern and Western seaboards. To U. S. producers in these areas, the trickle has suddenly become a torrent in this year of intense competition. Freight rates are low because returning freighters frequently use the cement for ballast; and the import duty is also unreasonably low, according to U. S. producers. Domestic inventories of unsold cement have increased by 30% to about 38 million bbl. in the past 2½ years despite the biggest sales in history in 1959.

▶ **That Depletion Allowance** — To add to this year of woe came the depletion allowance ruling that will drive taxes upwards at the expense of profits for many companies. This allowance is a tax deduction designed to encourage new mineral exploration. It's percentage varies according to the mineral and the company's gross income from mining.

In the now-famous Dragon Cement Co. case, a decision was made by the Supreme Court, which allowed cement producers to base the allowance on the much higher value of their finished product rather than on the raw materials going to the kiln.

The recent change in the Internal Revenue Code, restoring the allowance to the lower value of the kiln feed, does not go into effect until Jan. 1, 1961. In the meantime, cement makers are pondering an analogous case (sewer pipe made from fire clay) where depletion allowance on final product was disallowed.

They fear that the Treasury not only will reject claims for tax refunds based on the Dragon case, but also may even assess additional taxes for the period in which the more liberal ruling was in effect. Not all companies took advantage of the higher depletion allowances; among those that did, profits were increased up to 25%.

Future's brightened by new products, new population

Despite the gloomy picture through the first half of 1960, many industry observers look to the near- and longer-term future with optimism. They base their enthusiasm on several factors:

▶ **Expansion** — During the 1950s, Portland cement capacity in the U. S. increased from 268 to over 400 million bbl./yr. Cement plants in operation increased by 22 to 172. A great deal of this expansion was based on the simple axiom that a growing population will need more roads, houses and public facilities, even after the postwar expansion surge was fulfilled. There is no reason now to refute this thesis, although short business recessions, as in many other industries, can play short-term hob with long-term trends.

Hence, the feeling in the industry is that the abrupt reversal experienced in 1960 will be only temporary and that the upward trend will be resumed, although perhaps more moderately.

This optimism is based in part on recent government indications that the highway program will be somewhat accelerated, and partly on the hope that no matter which party emerges triumphant in the election, it will push for increased government spending in the areas of schools, highways, and public housing and buildings. Such progress is sometimes slow, however. It usually takes about eighteen months from the time a highway commitment is made before the first concrete is poured.

▶ **Beauty and Utility**—Perhaps the biggest hope for the future is in new applications of concrete. The old concept of concrete structures as square and massive is fast being replaced by an image of graceful curves and unusual colors and surface textures which makes for many new applications.

This revolution in the appearance of concrete structures has been made possible by the development of new construction techniques, based on ultimate strength design, a term which describes the concept of utilizing every bit of the higher strength made possible with modern concrete and steel.

▶ **Shell Concrete**—The strength of an egg shell is well known; an ordinary chicken egg can withstand an end pressure of 75 psi. When this principle is applied to reinforced concrete, roofs of 3 in. or less in thickness can be used to cover spans of several hundred feet.

Shell concrete buildings have appeared in the shapes of domes, barrel shells, undulating curves, folded plate roofs and hyperbolic paraboloids. This method of construction provides large areas of unobstructed floor space.

▶ **Prestressed Concrete** — Frequently called "concrete with muscles," prestressed concrete combines the best properties of steel and concrete. The steel reinforcement in a concrete beam or girder is stretched and anchored at the ends of the beam or through bond with concrete. Since the concrete is placed in a state of compression, it is able to withstand much heavier loads than before.

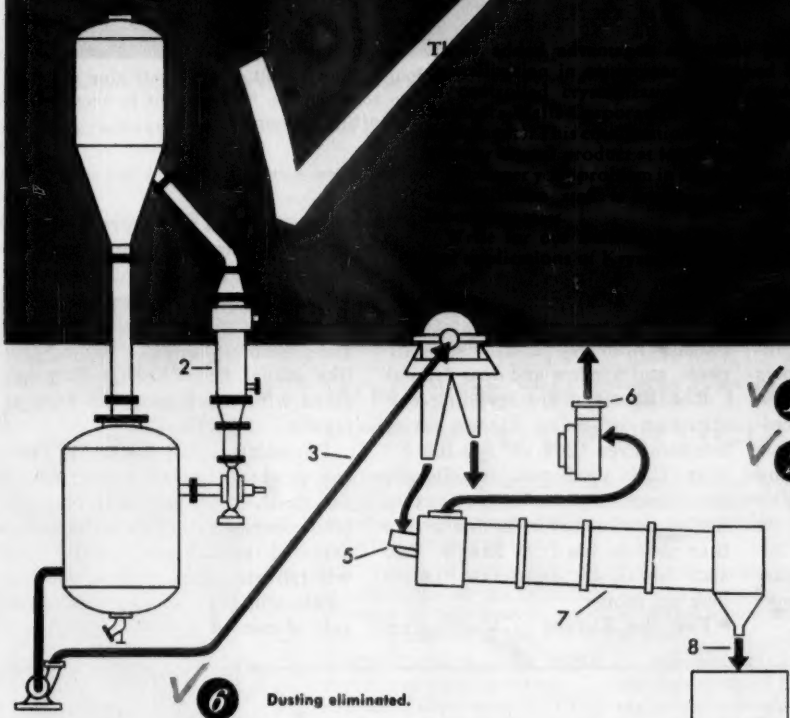
Advantages are apparent: bridges, roofs and floors can be designed with shallower members and longer spans than are feasible with conventionally reinforced concrete.

Twelve years ago, prestressed concrete was brand new in this country. Now, there are almost 400 plants turning out various concrete members for bridges, gymnasiums, factories, tanks, silos and pipe.

▶ **Precast Concrete**—Many designers and builders believe that precast concrete will become a major factor in concrete consumption as time goes by. The term "precast"

added

Struthers Wells KRYSTAL



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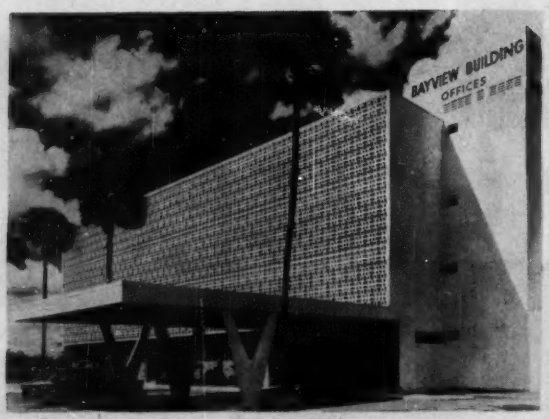


Concrete grill blocks form a lacelike facade for a Florida office building. Curtain wall is not only decorative but helps to control light and temperature in the building.

Airport terminal building in St. Louis is striking example of shell concrete construction. The interior is over 400 ft. long without supporting columns.

refers to any unit (often up to 16 ft. square) cast either at a central casting plant or at the building site, which must subsequently be moved before it is installed in place.

Use of these slabs becomes increasingly important as new ways are found to join them in the various patterns demanded by architects. Several types of multiple dwellings have been designed, using slab construction, for the ACTION experimental housing project in East Hills, Pittsburgh, Pa. A 20-story concrete slab building is currently being erected in Europe, where the technique originated.

In the Soviet Union, concrete is by far the most-used building material for housing and public buildings. More than 2,000 factories there turn out floor slabs, wall panels, interior partitions, staircases, and window and door frames.

The Russians are speeding construction by using higher curing temperatures (207 vs. 140-160 F.) than U. S. producers do. Despite the volume of concrete construction, Soviet workmanship is far poorer than that in the U. S. Result: Russian buildings depreciate faster, look old sooner.

▶**For the Future** — Many other concrete forms and expressions are being used today, limited only by the imagination of architects and designers. Among them are concrete made with lightweight aggregate, concrete blocks split to look like stone, and blocks which are faced with other materials such as plastic.

Chemicals added to concrete mix can produce unusual properties in the finished product that may extend concrete's use into hitherto unexplored applications. Only time will tell what impact these developments will have on production and sale of cement.

Compromise Is Key To Small-Company Growth

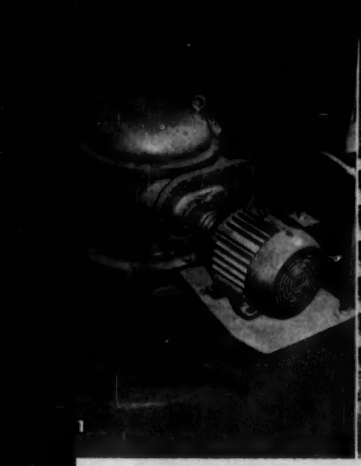
While a small growth company usually generates enough capital for such necessities as replacement, expansion and improvement, its capital requirement for "new projects" usually exceed available funds by anywhere from fifty to several hundred percent.

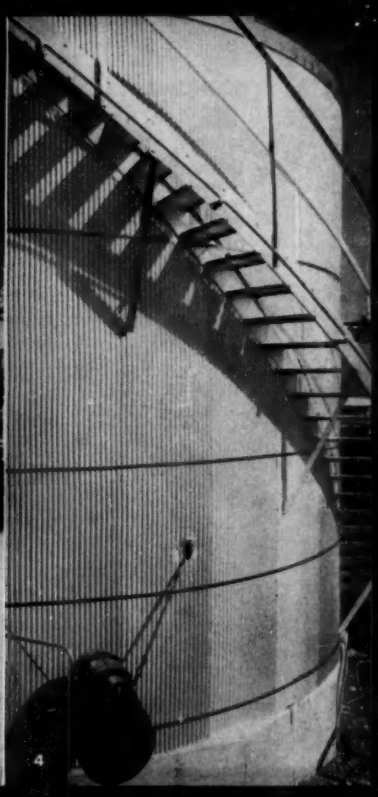
According to Foster Grant's R. L. Purvin before the American Chemical Society (ACS) in New York last month. "Without money, it is either compromise or forget the project. It is here, according to Purvin, that the art of capital management takes over from the science of capital management.

"Our first step is to examine the project and determine how we can build something less than the ultimate plant. We go ahead on the premise that if we can get a certain bare minimum of plant in operation, certain benefits will accrue —benefits that will offset the 'scientific' advantages offered by the 'minimum economic unit' with all appurtenances. To be sure, we do not compromise with safety, but we often deviate from accepted service and we also deviate from capacity standards.

"Often this deviation from the ultimate plant is merely a stretch-out in the construction program—the plant is finished literally during the first year or two of operation. The rate of completion will depend on the success of the venture, and this success gives added incentive to the operating personnel to show a profit.

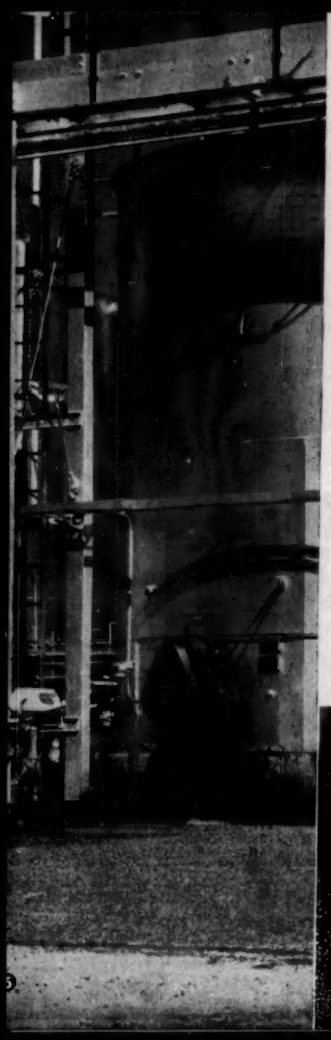
"The delayed items can be conveniences, such as extra toilet and locker facilities, shops, warehouses and offices, tanks, paving, painting, spare pumps and compressors, spare parts and many other items, both large and small, all of which can add up to a very sizable amount if you are willing to comprise and





1. Ore purification in pressure vessel with Nettco tank top turbine mixer.
2. Butadiene blending with Nettco side drive mixers having replaceable, mechanical seals.
3. Violent agitation as produced by Nettco's unique combination of turbine and propeller drives.
4. Maintaining product uniformity in Styrene storage tanks with Nettco side drive mixers.
5. Blending with Nettco side drive mixer in storage tank containing 20% caustic solution.
6. Small batch blending with versatile Nettco portable mixer.
7. Standardization of finished product with rugged Nettco vertical turbine mixers.

Improved Processing through Engineered Agitation



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FLUID MIXING demands specialized, highly technical know-how. There is no single mixer which is "best" for every job. Only a mixing specialist can combine and coordinate agitation technology with mixer design and optimum horsepower to achieve an exacting result.

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BACKED BY A FULL LINE . . . side drive, tank top, portable or tripod and continuous pipeline mixers . . . and thousands of performance-proven installations, like those illustrated, NETTCO can provide invaluable help in determining your fluid mixing needs. See *Chemical Engineering Catalog* or *Refinery Catalog* for our nearest representative, or write for Bulletin 582, NETTCO CORPORATION 87 Tileston Street, Everett 49, Massachusetts.

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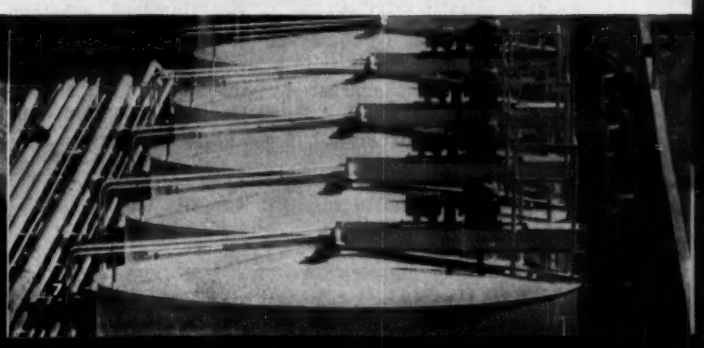

willing to worry the project through.

"Using this approach, the cost of additions is seldom greater and often is less than if they were constructed at the outset. It is sometimes possible to effect substantial savings by using your own work force and by proper timing of purchases and erection of additional plant.

"Far tougher and riskier compromises must be considered when the stretchout falls short of the original plan. Then, we must try to cut the size of the plant to perhaps 25 to 30% of the accepted minimum economic size.

"We know that such a plant won't make as much profit—in total dollars or as a percent. It may not do much more than break even. But it might prove our ability to make and market the product, and may allow us to develop a technical proficiency in processing that will eventually lead to substantial operating savings in the ultimate plant."

Dynamite's Future Seen Void of New Demand

In closing the company's dynamite plant near Richmond, Calif., last month, Atlas Powder President Ralph K. Gottshall explained that the ammonium nitrate revolution "is likely to eliminate any further significant increases in demand for dynamite—it also has idled much dynamite capacity that is not likely to be needed in the foreseeable future."

As a part of its long-range program, Atlas has been consolidating explosives production facilities into large-volume, versatile, integrated plants near Joplin, Mo., and Tamaqua, Pa., for maximum operating efficiency and customer service. These moves, said Gottshall, were made to counter the effects of a major technological change in the industrial explosives market—the replacement of dynamite in a large portion of that market by ammonium nitrate, which Atlas makes at its integrated plants but not at Richmond.

Read Your Government Research Contract Carefully

Speaking before the ACS in New York last month, consultant D. B. Keyes took issue with certain government agencies' belief that it is their right and privilege to own all of the patents resulting from the research for which they have paid. In some cases, they have gone further and demanded ownership of patents on certain important inventions for whose development they have not paid—so-called "background" patents.

Keyes argued that the government does not and should not own inventions conceived under government research and development contracts; it has not really paid for them and it certainly has not paid for the background material.

"The contractor whom the government has asked to do the work presumably has already done competent work in the particular field; otherwise, why ask him to undertake the contract? It is reasonable to assume that the government is interested in obtaining satisfactory results as quickly as possible. Will it pay the contractor for his particular knowledge acquired over many years and the expenditure of many of his own dollars? It will not!"

One proposal to alleviate this situation, he notes, is the suggestion that the director of the National Science Foundation (NSF) decide which patents should be owned by the contractor and which by the government. It is felt by NSF that no rigid rule should be established for federal agencies in disposing of what is termed "government patent rights." The NSF people feel it is very important to have freedom in making a decision.

In deciding whether the government should take title to a patent, they feel certain factors should be weighed—for example, whether the public health, safety or welfare is involved; whether the government has been the prime developer of the field of technology involved; or whether other equities affecting the situation would also have to be considered.

Another proposal is to leave to the head of the particular agency the decision of who "owns" the invention.

But, asks Keyes, "If the government acquires a patent covering an invention produced under the contract, will the government defend it?" It never has, Keyes claims. It never has sued an infringer and it never has issued a royalty-bearing license on such a patent.

The result: "In industry it has reached the point that certain prominent compaines say that they literally cannot afford to accept research contracts from the government in areas where they have tremendous knowledge, simply because of the patent situation. If companies cannot afford to accept these contracts, it becomes obvious that important government-sponsored research efforts and, in particular, defense programs cannot help but suffer."

Process Industries Up Research Spending

Some 400 corporations, representative of U. S. industry, will spend an average 10.7% more for development of new products and processes in 1960, compared with 1959, according to a nationwide, midyear survey by the American Management Assn.

Process industry increases in budgeted costs directly associated with development of new products and processes are as follows:

Industry	1960 Increase Over 1959 Budget
Chemicals	11.4%
Food & beverages	13.1
Paper & paper products	9.6
Plastics & molded products	14.6
Rubber & rubber goods	10.8
Stone, clay & glass	19.2
Textiles	8.3

The 400 corporations spent an average of 3.7% of 1959 sales for product development that year, the survey shows. The leading industry was electronics with 7.7%, followed by instruments and control equipment, 6.1%, and pharmaceuticals, 5.7%.

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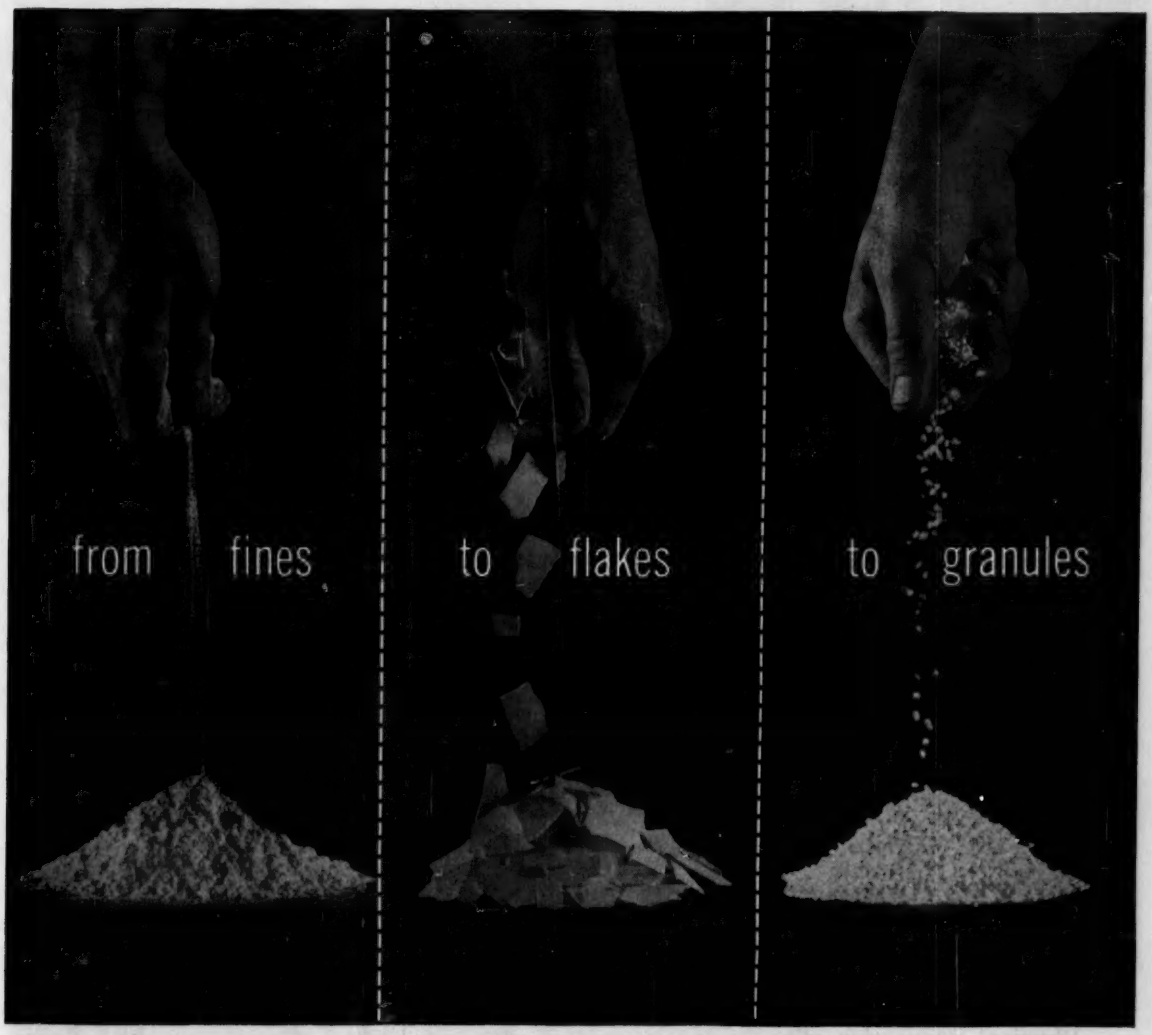
A-1334



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Quality control? Production control? New granular product development? Marketing or sales? If any or all of these are your responsibility, you'll want the advantages you can get with the Allis-Chalmers compacting process.

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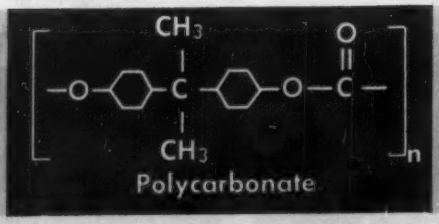

Combining properties of metals and plastics, polycarbonate resins open new doors to hosts of design innovations.

POLYCARBONATES: THERMOPLASTICS FOR THE '60s

Having completed construction of its 5-million-lb./yr. polycarbonate plant on schedule, General Electric has entered a new plastics field that, experts predict, will expand ten times during the next five years, skyrocket by 1970.

Stretched across 162 acres along the Ohio River, near Mount Vernon, Ind., the new plant was put in operation last month, is the result of $11 million spent for research and development. It will produce polycarbonate thermoplastic resin, Lexan, by combining bisphenol-A with phosgene (carbonyl chloride).

Hydrochloric acid is split off during condensation of the bifunctional monomers, and the resin, consisting of bisphenol groups joined together by carbonate linkages, goes through the usual blending, coloring and pelletizing operations.

Offering a combination of toughness, impact strength, heat resistance and dimensional stability, Lexan polycarbonates have trickled out of pilot plants since 1957, have already been used in over 300 commercial applications to meet special requirements other plastics couldn't cope with.

Physical properties of polycarbonates

Color	Light amber, transparent
Specific gravity	1.20
Refractive index at 25 C.	1.586
Tensile impact, ft.-lb.=cu. in.	600–900
Tensile yield strength, psi.	8,000–9,000
Tensile modulus, psi.	320,000
Elongation, %	60–100
Compressive strength, psi.	11,000
Compressive modulus, psi.	240,000
Flexural strength, psi.	11,000–13,000
Flexural modulus, psi.	375,000
Shear yield strength, psi.	5,400
Melt viscosity at 300 C., poises	4,000–6,000
Brittle temperature, C.	<–135

More to Come—Because of a wide variety of polyphenols available, more than 50 different polycarbonates have been synthesized, and active development programs into new resin variations are under way.

Only three years ago, *CE* announced the birth of polycarbonates, which at that time had been developed independently and almost simultaneously by General Electric, at Pittsfield, Mass., and Farbenfabriken Bayer, at Uerdingen, Germany. Since then, polycarbonates have increasingly stirred the curiosity of a few giants in the plastics industry.

While Union Carbide is now studying these resins in the lab and feeling the market's pulse, Columbia-Southern already has a 1,000-lb./day pilot plant at Barberton, Ohio, and Mobay, Bayer's U. S. affiliate, has started commercial production at its New Martinsville, W. Va., plant. In Japan, Edogawa Chemical, Idemitsu Kosan and Teijin Kasei have pilot plants, are now bickering over patents.

A glimpse at some aspects of GE's Lexan resin can give an explanation for this worldwide flurry of interest in polycarbonates.

Physical Characteristics — With strength comparable to that of many metals, Lexan resin can withstand repeated impacts while exhibiting minimum cold flow, has been used as a replacement for metals in various applications.

Its tensile strength, slowly decreasing at rising temperatures, is much better than polystyrene and acrylics where tensile strength falls rapidly. And its elongation rate at rising temperatures shows a more favorable picture than that of nylon.

The tensile yield point and tensile ultimate strength are about 9,000 psi. at room temperature and 13,000 psi. at temperatures less than −60 F.

Water absorption is lower than that of other plastics. At room temperature, a ⅛-in. specimen in water reaches equilibrium, after 125 hr., with 0.35% water absorption.

Plastics under stress may continue to deform with time. But a molded Lexan part reaches its final deformation rapidly; total deformation after 24 hr. will be about 75% of that obtained in one year. And creep distortion can be eliminated if static loads are kept under 2,000 psi.

Lexan's resistance to aging is good, with a dimensional change of only 1 mil./in. recorded after a 90-day aging at 125 F. The resin also shows high-volume resistivity and dielectric strength, with low losses at low frequencies.

Replaces Brass, Bronze — Because it is a highly ductile thermoplastic, Lexan lends itself to economical production methods such as injection or blow molding, film extrusion, vacuum forming and cold forming. And its impact resistance can be matched only by that of metals or glass-fiber rein-

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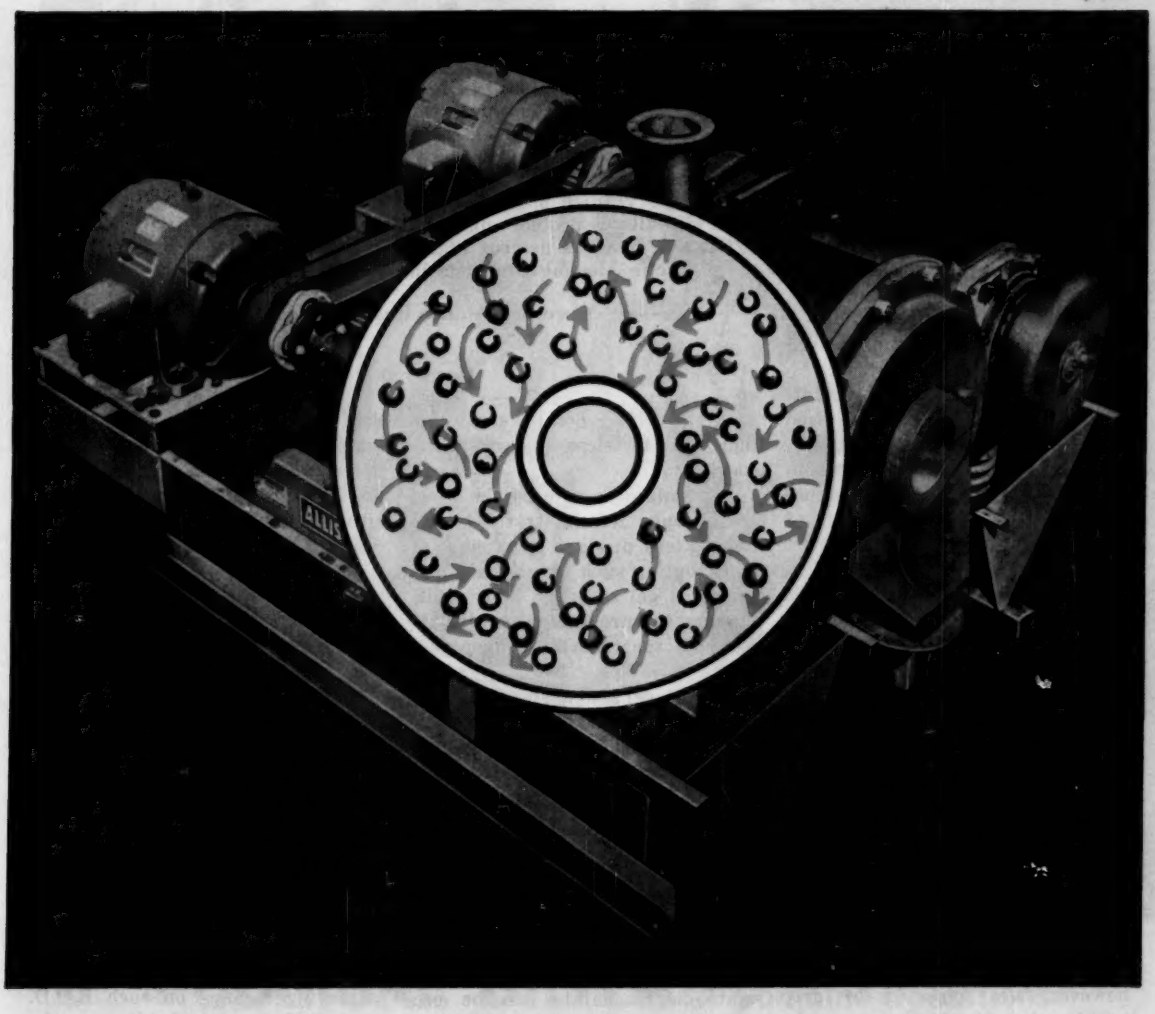


Vibro-Action keys performance

makes this 30" vibrating mill up to 30 times more productive!

You get maximum efficiency with this remarkable grinding action. With grinding media occupying approximately 80% of mill volume, the grinding charge vibrates at high speed. Grinding media works individually and as a mass between the center tube and shell liners.

Through this combination of high percent media loading, mass rotation and multiple impact, the charge swells to fill the entire mill with grinding fury. Top performance means this small vibrating mill outproduces a tumbling mill as much as 30 times per unit volume.

See your A-C representative for the details, or write **Allis-Chalmers,** *Industrial Equipment Division, Milwaukee 1, Wisconsin.*

Wide-range versatility. *Listed here are just a few of the many materials that are being processed efficiently with an A-C vibrating mill:*

Alumina • Aluminum-nickel alloy • Aluminum powder • Asbestos ore • Asbestos fibers • Barite • Blast furnace slag • Boron carbide Calcined magnesite • Coke • Copper ore • Dolomite • Feldspar Ferro-alloy, high-carbon, low-carbon • Glass shot • Hematite Ilmenite • Manganese ore • Kyanite • Limestone • Mica • Paint pulp Perlite ore • Phosphate ore and concentrates • Pigments • Quicklime Shale • Silica sand • Silicon carbide • Talc • Tungsten carbide Urea powder • Wood fibers • Zircon sand • Zirconium oxide.

A-1386

forced thermosetting plastics, which, however, do not have its versatility.

Vacuum-formed Lexan transition couplings have successfully replaced brass in delicate radar components at substantial savings. Polycarbonates outperformed bronze in molded impellers for self-priming convertible jet pumps.

Cold-working techniques such as hammer forging, coining, stamping, drawing and die bending are possible and the same type of equipment that's used on brass, aluminum and copper can be used on Lexan resin.

Coatings can be applied by painting, dipping, spraying or fluidized bed techniques using Lexan powder.

As thermoplastics, polycarbonates melt and burn in the presence of a flame but once the source of heat is removed they won't support combustion.

Lexan resin is stable in aliphatic hydrocarbons, salt solutions and aqueous acids, is partially soluble in aromatics, dissolves in chlorinated aliphatic and aromatic hydrocarbons, some of which have been used for solvent-cementing Lexan parts.

A strong market for polycarbonates is developing in the electrical, aviation, automotive and photographic industries. In its natural color, Lexan sells at $1.50/lb. (down from $2.50/lb. in 1957) for 10,000-lb. lots, and at $1.75/lb. in any of 14 available colors. Current prices, however, are expected to drop within the 90¢/$1.20 range by 1962.—**General Electric Co., Pittsfield, Mass.** **68A**

Newsworthy Chemicals

Page number is also reader service code number

Polycarbonates: thermoplastics for the '60s.....68A
Cellulose powder is used in foods, paints, drugs.....70A
Low B.O.D. starch improves weaving, cuts pollution.....70B
Borated dextrins produce stable adhesives.....72A
Cellulose-digesting enzyme prevents intestinal distress.....72B
Synthetic mica paper is now available.....72C
Phenolic varnish makes flame-retardant laminates.....72D
New additives protect engines, deactivate copper.....72E
Organic biocides destroy algae and bacteria in water.....72F
Polycyclic Alcohol cuts costs in perfume formulations.....72G

More details, use Reader Service Card

Cellulose

Purified grade is used in foods, paints and drugs.

Extremely firm and opaque gels with creamy textures and stability were accidentally discovered years ago while experimental work with aqueous cellulose solutions was under way.

Further research on these cellulosic gels has lead to "Avicel," a snow - white, free - flowing and highly purified cellulose powder that is tasteless as well as odorless.

Recognized as safe by the Food and Drug Administration, this calorie-less product is capable of contributing such functional properties as gel stability, body, bulk, opacity, texture and palatability to a whole spectrum of convenience foods.

Dry Avicel also absorbs fats and oils to such an extent that syrupy and oil-base foods can be converted to granulated forms. Even peanut butter can now be converted into a dry free-flowing powder that is literally sprinkled on bread.

In the pharmaceutical area, this absorptive capacity permits Avicel to be used as a carrier for vitamins and other products. Oil- and water-based paints can be produced in an easier to handle, dry powder form, which can be converted to normal paint consistency by addition of proper solvents.

For preparation of chemical derivatives, Avicel has advantages over conventional fibrous cellulose. It is extremely pure (Mg, Fe, Cu and Mn concentrations are in the 2-20 ppm. range), is highly reactive and has a completely different physical form. It is stable and can be stored under normal humidity and temperature conditions. Its equilibrium moisture is under 6%.

This crystalline cellulose is soluble only in dilute alkali, but water dispersions can be made. Still in the experimental stage, while uses in cosmetics and other fields are being sought, Avicel is available in semicommercial quantities.—**American Viscose Corp., Marcus Hook, Pa.** **70A**

Low B.O.D. Starch

Product facilitates weaving operations and waste disposal.

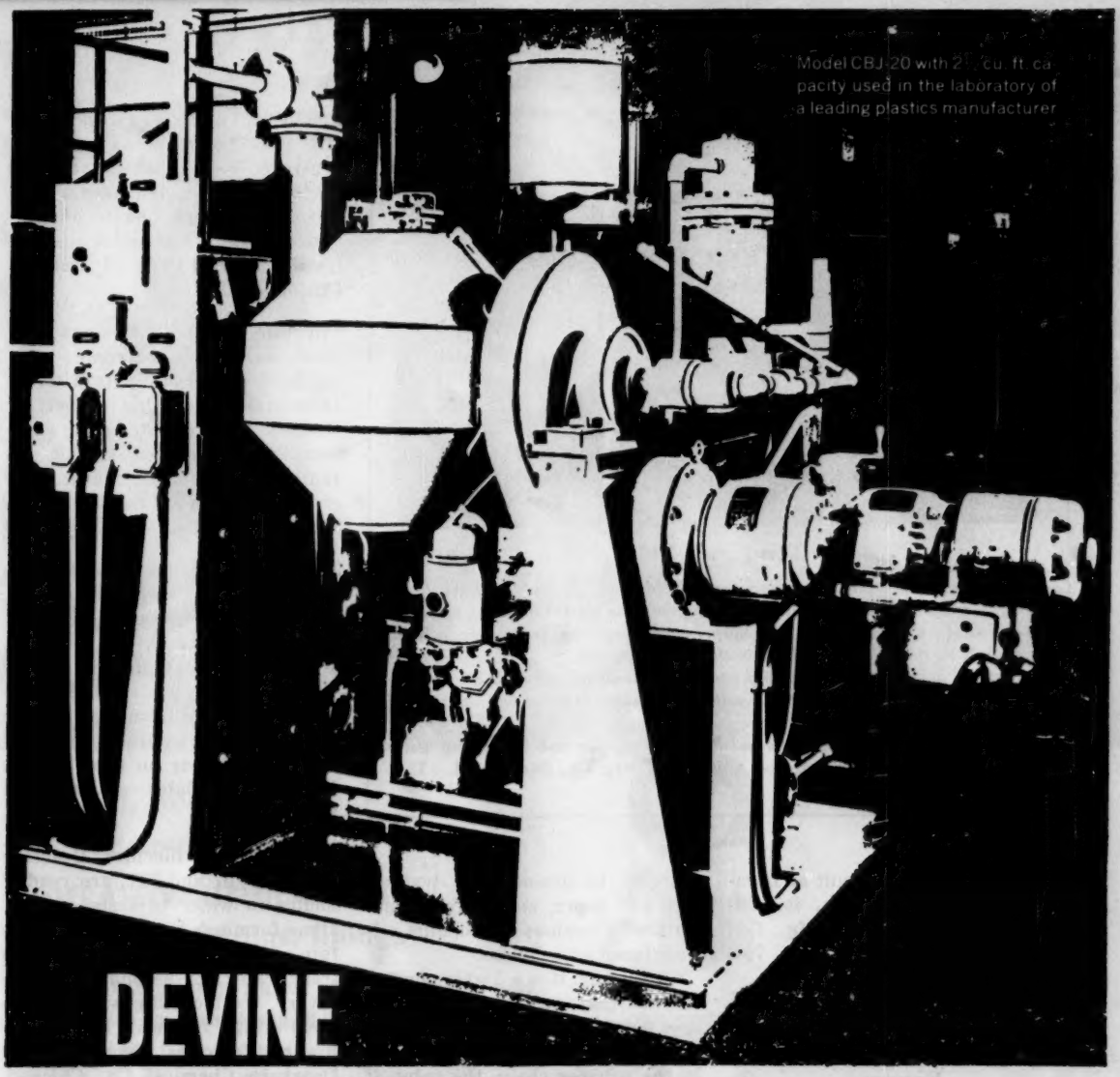
A warp-sizing starch with 70% less biochemical oxygen demand (B.O.D.) than ordinary starch and nearly twice the effective weaving protection is being marketed under the brand name Oxytrol.

Stream pollution, a problem almost as old as the textile industry, is considerably controlled by the reduced warp-size B.O.D. Besides achieving savings on such B.O.D. control factors as holding ponds, treatment systems and high disposal dilution measures, Oxytrol starch gives greater weaving protection.

In mill trial runs, cotton warp sizes made with the new starch at 5 to 7% solids equalled the performance of warp sizes made with ordinary starch, at 10-12% solids.

A granular, free-flowing and chemically modified starch, Oxytrol can be used over a wide temperature range, from room temperature to boiling. It is mildly alkaline, desizes easily.

Currently available in limited quantities, the product will go fully commercial late this year, when a



DEVINE CONICAL DRYERS Combine Operations and Cut Costs

Designed to mix and vacuum dry even the most delicate materials with a gentle roll-and-fold blending motion, the Devine Standard Conical Vacuum Dryer insures the safest possible drying and mixing procedure. Devine's conical dryer gives you complete recovery of all processed materials and can be so easily and quickly cleaned that most users find handling time is cut in half.

The Devine Conical Vacuum Dryer is a complete, self-contained unit, available in 2½ to 233 cu. ft. capacities and equipped with condenser, hot-water heating system, pipe, vacuum pump and controls. Smaller units like the above, need only water and power connections, and are shipped completely mounted. Larger installations are assembled under the direct supervision of Devine engineers.

We suggest that you explore the many advantages of vacuum mixing and drying. Devine's experienced engineers would like to show you just how easy it is to cut your production time and costs with the Devine Conical Vacuum Dryer. For further details about vacuum drying and mixing—or for answers to your particular processing problem—write us today.

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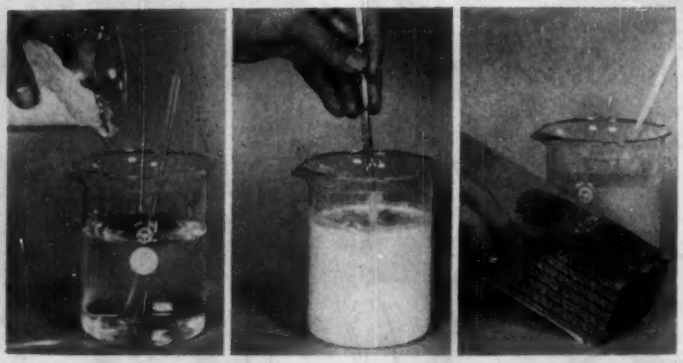
Dextrin adhesives:



. . . mix . . . stir . . . apply

Three new dextrins in powder form, Koldex 20, 30 and 40, have been made for a wide variety of adhesive applications by formulating regular specification dextrins with borax, preservatives and defoamers into a prepared liquid adhesive, which is then spray dried.

Borated dextrins meet exacting viscosity standards and dissolve readily in cold water to produce stable adhesives in the 1,000-1,500 centipoise viscosity range.

Packaged in 50-lb. bags, the powder is ready for use by mixing with water 1 hr. before application.—**A. E. Staley Mfg. Co., Decatur, Ill. 72A**

new plant now being built at Decatur, Ill., by Staley Mfg., is completed.—**A. E. Staley Mfg. Co., Decatur, Ill. 70B**

Enzyme

Digestive disorders are on the way out with a new enzyme.

Isolated from a mold strain of *Aspergillus niger*, a cellulose-digesting enzyme trademarked Cellase 1000 is the most recent weapon used in geriatric digestive disorders and nutritional insufficiencies, dyspepsia, flatulence and other gastrointestinal disturbances.

Approved by the Food and Drug Administration, Cellase 1000 facilitates the digestion of difficult vegetables such as cucumbers, cabbage, carrots, so that people who have trouble with these foods can be allowed a greater cellulose bulk intake without incurring distress.

The high cellulelytic activity and uniform makeup of Cellase 1000 can also be exploited in textiles, pulp and paper, and in the manufacture of various hydrophilic colloids based on cellulose.

Chemically, it is a highly purified enzyme that depolymerizes cellulosic polysaccharides of high molecular weight into smaller fragments. In the polymer chain, the point of attack is the 1,4-B bend that links D-glucopyranose residues. Nutritional utility of the end-products depends on how far this hydrolysis can go with the particular type and state of cellulose used.—**Wallerstein Co., New York. 72B**

Briefs

Synthetic mica paper, Synthamica 202 (m.p. 1,365 C., operating temperature 1,000 C.) is now produced in pilot-plant quantities for use in high - temperature transformers, motors and capacitors. This mica has dielectric strength of 600-1,000 v./mil and volume resistivity of 5×10^{-15} ohm cm, at room temperature. With a tensile strength up to 10,000 psi., it makes a good material for components of electronic devices and guidance systems.—**Mycalex Corp. of America, Clifton, N. J. 72C**

Phenolic varnish Resinox 495, produces a flame-retardant, high-grade electrical laminate with excellent cold punching properties. Resinox 495 laminates are recommended for printed circuits in radio, TV and electronic computers.—**Monsanto Chemical Co., Springfield, Mass. 72D**

Zinc dithiophosphate and N,N¹-disalicylidine propylenediamine, tradenamed Antioxidant ZDP and Metal Deactivator, respectively, are two new fuel and lubricant additives. ZDP protects engines against cam and lifter wear. Metal Deactivator counteracts harmful effects of copper on gasoline, jet fuels and distillates.—**Ethyl Corp., New York. 72E**

Liquid organic biocides, Dearcide 702, 703, 707 and 717, are readily soluble in water to destroy algae, slime-forming bacteria and sulfate-reducing bacteria. Products treat water for secondary oil recovery, treat cooling water in recirculating systems, in cooling towers and heat exchangers.—**Dearborn Chemical Co., Chicago. 72F**

A polycyclic alcohol, trademarked Sandela GD, is the first aromatic to offer the characteristics of natural sandalwood oil at one-third the cost. It can be used in perfume formulations for such products as soaps, detergents, cosmetics and aerosols. — **Givaudan-Delawanna Inc., New York. 72G**

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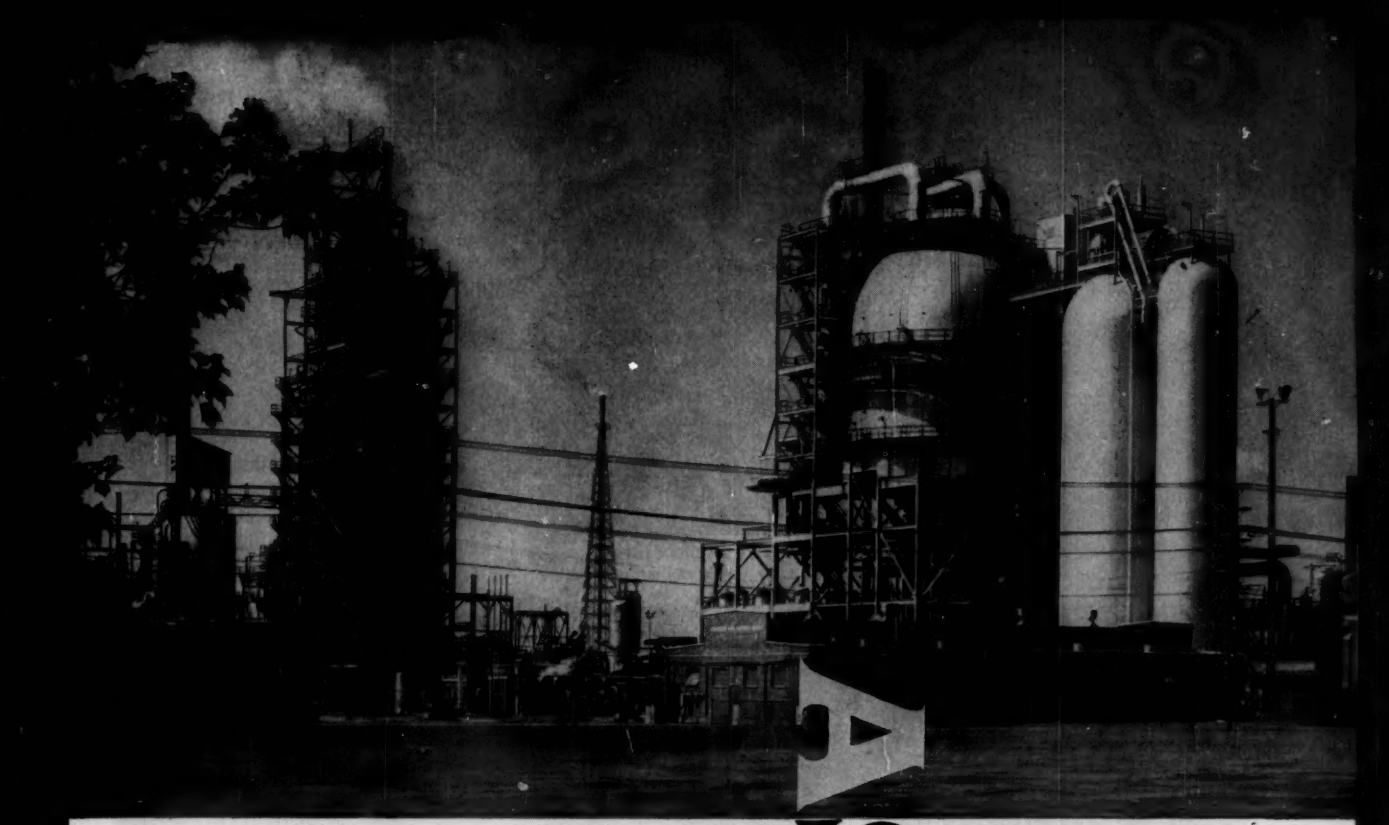
about any item in this department, circle its code number on the

Reader Service

Postcard (p 187)



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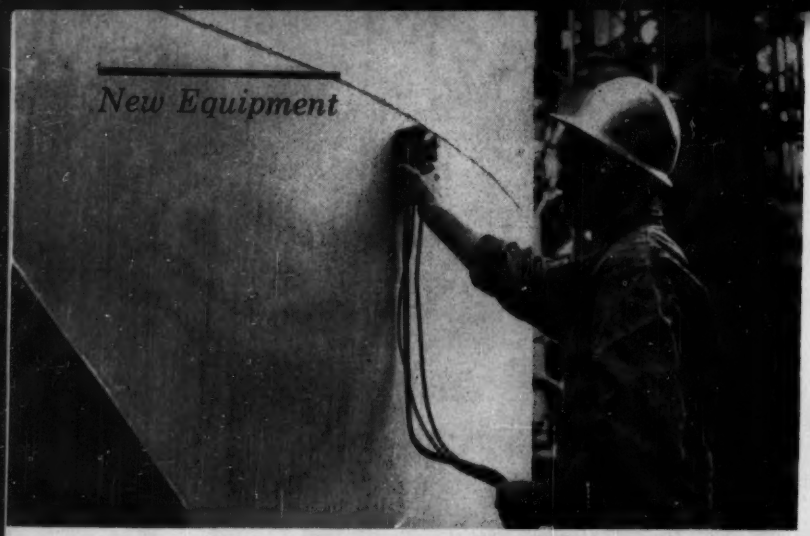
Montreal, P.Q., 1400 Norman St., Lachine, Phone: Melrose 7-3591



Ultrasonic device measures tank wall thickness (above), reports corrosion or other wear to central monitor, which makes record.

SEARCH FOR WEAK SPOTS WITH PLANT ON STREAM

Ultrasonic device can peer through steel walls, reveal hidden ravages of corrosion or detect weak spots in welds and tank bottoms.

Hidden corrosion and internal wear on pipes, tanks, distillation towers—almost anything metal—can be searched out and measured with new techniques in pulse-echo ultrasonics. Unlike many similar test procedures, the system, called Ultragauge Inspection, can be done on hot, onstream process equipment.

Onstream inspection gives operating advantages to the plant manager. He is able to obtain:

- Maximum safe service from each operating component.
- Maximum running time between scheduled turnarounds, since the condition of critical areas can be known at all times.
- Minimum lost time during turnarounds, since trouble spots are already pinpointed.

The system employs the basic principles of pulse-echo ultrasonics, or so-called "silent sound," to measure wall thickness. Ultrasonic pulses, introduced into a metal surface, are reflected by the other side of the wall. The total depth of penetration is measured and recorded.

▶ **Just a Hairline**—The introduction of accurate ultrasonic depth-measuring devices was speeded by the development of the focused ultrasonic transducer, which allows a hairline width of ultrasonic sound to be focused on the surface of tubular and other metallic material. Such extremely fine focusing of the beam is said to allow precise thickness measurements of individual pits to an accuracy of 0.005 in.

Since ultrasonic signals will not travel through air, water is used as a medium between the crystal transducer and the equipment being inspected. The ultragauge system uses a patented device called an Ultracoupler.

Two men operate the equipment in the field. One sets up the monitor unit in a central location, records and interprets the signals fed to it from the remote scanner. Second man operates the scanner, moving it over the equipment being examined. The men use two-way radio to keep in direct contact, discuss any unusual signals that may be transmitted.

▶ **Versatile Service**—Special adaptations of the Ultracoupler device are used to examine welds that protrude from the smooth surface of tanks or vessels, and to inspect an entire tank bottom or other large, flat area. Inspection can be performed on hot lines operating at temperatures in excess of 1,000 F.

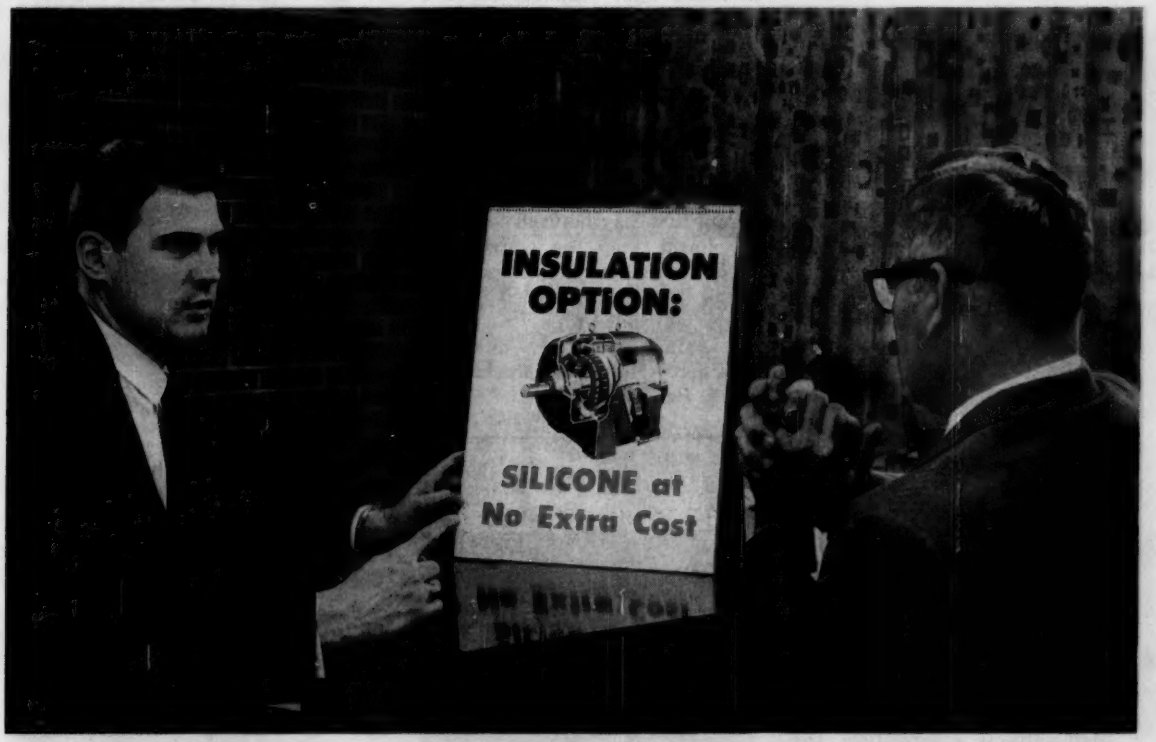
Ultrasonic impulses are inked onto a log or chart, making a permanent record of such things as wall thickness, fatigue cracks, corrosion pitting, normal wear and internal flaws, and condition of welds, tank bottoms, pressure vessels and other equipment.

The Ultragauge system has been used almost exclusively in the oil

(Continued on page 76)

SILICONE NEWS from Dow Corning

What Price Difference?

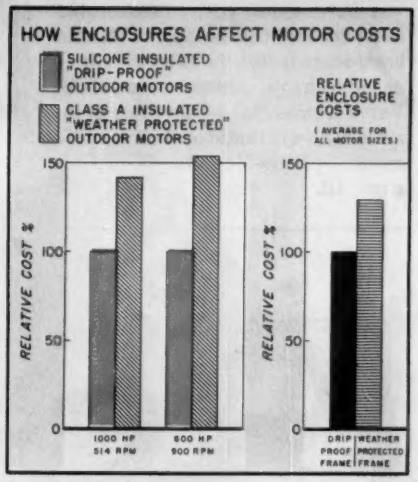


There's No Price Premium . . . Just Savings . . .When You Specify Silicone Insulation

For Outdoor Locations: You can save 30% and more on initial cost of form-wound motors by specifying silicone insulation systems made with Silastic, the Dow Corning silicone rubber. Here's why: 1) Silicone insulated motors are now available at no price premium; 2) The insulation system itself is self-protecting, shrugs off weather, humidity, corrosion, dust, even flooding. There's no need for elaborate enclosures that push motor prices up and up. The chart (right) shows how much you save by specifying silicone insulated open motors.

For Indoor Locations: Where ambient temperatures are high, where corrosive fumes or industrial contaminants are present; where relative humidity is pushing 100%; where motors are hosed down — in all these applications and others, too, expensive motor enclosures, and often expensive ducting as well, can be eliminated by specifying silicone insulation.

For Any Location: Silicone insulation systems increase motor service factor by as much as 15 to 30% because of their greater thermal stability. This increased service factor means there's no need to overmotor for occasional overloads . . . and suffer the power factor penalty of part loaded induction motors.



This chart shows one of the ways you save by specifying motors insulated with Silastic.

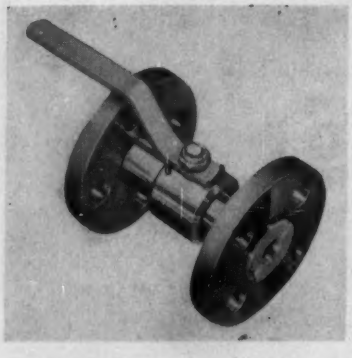
New brochure on Silicone Insulation. Write for your free copy. Address Dept. 1810a

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

and petrochemical industries until now. — **International Inspection, Inc., Houston.** 74A

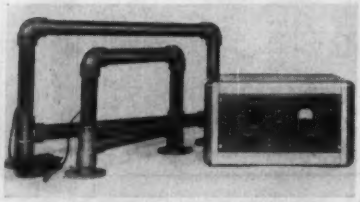


Flanged ball valve

Flanges rotate freely, permit handle position to vary.

Valve installations are speeded with new floating-flange ball valve. Simply line up valve and pipe flanges, draw up bolts loosely, rotate valve (through full 360 deg.) to position handle where desired, and tighten bolts.

Ball valve is quarter-turn, two-way-flow type with prestressed seats for driptight closure. Double back-seated seal is said to eliminate leakage around the stem. Valve comes in ¼- through 2-in. sizes with synthetic or Teflon valve seats. — **Hills-McCanna Co., Chicago, Ill.** 76A

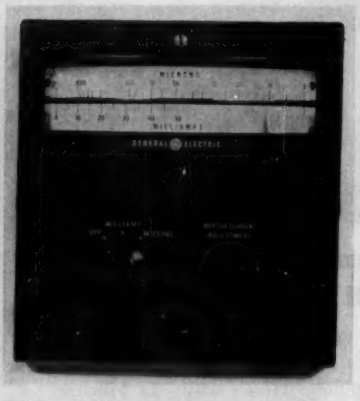


Metal detector

Ferrous, nonferrous metals and alloys trigger electronic unit.

Tramp metal concealed in other substances is detected by an electronic detector that locates all types of ferrous and nonferrous metals and alloys. It can be used to protect processing machinery or to check final products for contamination.

Called the Metabloc Metal Monitor, the unit consists of a search coil and a control unit. The coil is usually installed around a nonmetallic conveyor belt or weigh feeder. Any metal object moving through its field will produce a signal that may be used to trigger an alarm, stop the conveyor or divert the material containing the metal. The coil is sealed in polyvinyl chloride pipe to protect it against moisture, dust and weather.—**Morehouse Machine Co., York, Pa.** 76B



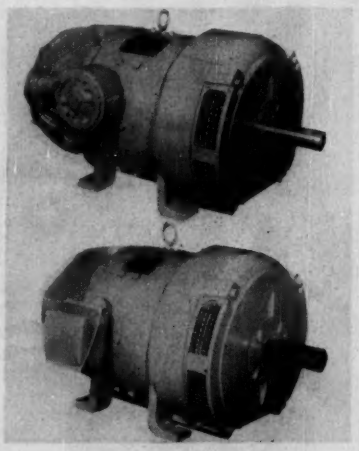
Vacuum controller

Vane-and-coil type mechanism offers accurate vacuum control.

Close-tolerance control systems can use a new vacuum gage indicator-controller that uses a vane-and-coil type control mechanism said to provide closer and more reliable control and more accurate indication than is possible with contact-type models.

Controller portion of the unit uses a pointer with a small metal vane that passes through a pair of sensing coils when the pointer reaches the set point. Presence of the vane activates an oscillating circuit than in turn energizes the controller relay. Since there is no contact, the pointer moves freely.

Instrument initiates control on either increases or decreases in pressure. Control point is adjustable over entire range, which is 1-1,000 microns.—**General Electric Co., Schenectady, N. Y.** 76C



Motor and generator

Insulation and ventilation are improved in new models.

Totally enclosed d.c. motor and generator, for both constant speed drives and drives involving fast speed changes and reversals, are now available in fan-cooled and nonventilated models in new standardized line.

New features claimed by the manufacturer include novel use of high-temperature silicone insulation for continuously operating machines with a temperature rise of only 160 F., and application of controlled ventilation in which blower and heat exchanger are mounted at the shaft end.

New units are said to have

For More Information

about any item in this department, circle its code number on the

Reader Service Postcard

(Page 187)

NO "NEW IMAGE" FOR US, THANKS

Seems nowadays practically everyone talks about "changing the image," "creating a new corporate image" or "giving the product a more dynamic image."

There's no such talk around Jenkins Bros.

When it comes to valves, we're as modern as tomorrow! But when it comes to a new corporate image, no thanks. Not for us. Our corporate image is nearly 100 years old, and it still suits us just fine. Here's why:

We'll Keep our Old, 1869-Model "Image" – Our Business Friends Seem to Like It

"A Fair Offer" was first published in 1869. Simple and forthright, it said that Jenkins Bros. wanted Jenkins Valves to be judged on performance. But — and this made the difference — not on performance in the average application, but rather in the very toughest one. Note that phrase, "the worst place you can find."

To us, it just naturally figures that the product which asks for the hardest job, will also be better, longer lasting and more trouble-free in regular, run-of-the-mill applications. Makes sense, doesn't it?

At intervals we republish "A Fair Offer" just because it does make sense to so many of our customers and friends. It's a useful reminder that products may change but *high standards* never go out of style.

JENKINS

Jenkins Bros., 100 Park Avenue, New York 17

Jenkins Bros

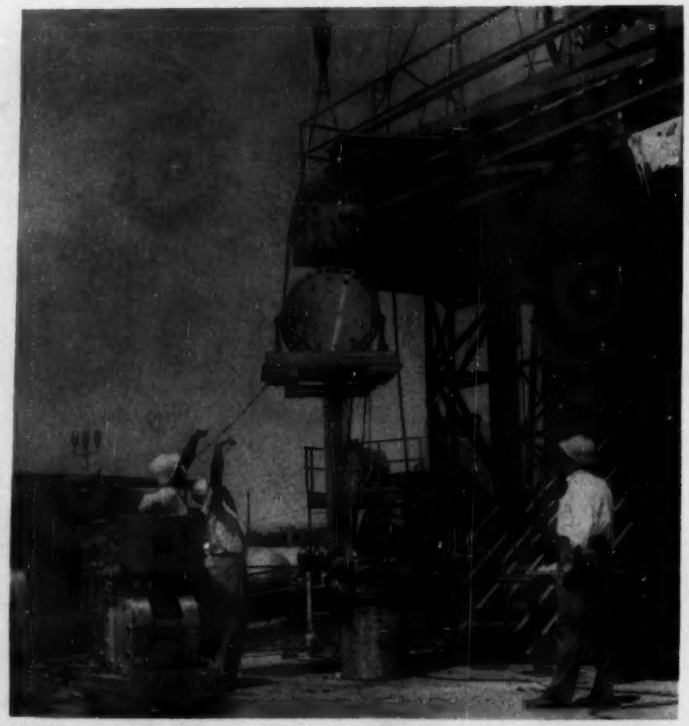
A FAIR OFFER

If you will put a Jenkins Valve, recommended for your particular service, on the worst place you can find . . . where you cannot keep other valves tight — and if it is not perfectly tight or it does not hold steam, oil, acids, water or other fluids longer than any other valve, you may return it and your money will be refunded.

Jenkins Bros

This early Jenkins Catalog carried the famous A FAIR OFFER which has appeared in every catalog since 1869.

Giant ball-valves master huge LOX, propellant flows



Up goes 6,500-lb. valve, one of four 18-in. ball-type units that control liquid oxygen (LOX) flow at Rocketdyne's Propulsion Field Laboratory, Santa Susana, Calif. Seven other 12-in. ball valves carry combinations of LOX, water and fuel. Valves are part of the vast array of equipment supporting the F-1 engine turbopump development program. They perform the challenging and herculean job of allowing propellants to flow to the turbopump at the staggering rate of three tons/sec., then cutting off the flood in half a second. And they do it at 600 psi., with some streams flowing at —297 F. The stainless steel valves were designed by Vickery Co., Oakland, Calif.—**Pelton Co., San Francisco.** **78A**

faster response, increased stability and insulation life. Armature inertia has been considerably reduced and insulation life under all temperature conditions is up to ten times that of conventional class B insulation. Commutating ability has also been increased.

Available in both industrial and explosionproof construction, motor is rated from ½ to 60 hp. at 300 to 3,500 rpm. Generator delivers ¾ to 40 kw. at 850 to 3,450 rpm.— **Westinghouse Electric Corp., Pittsburgh.** **76D**

Jet Cleaner

High-pressure unit cleans buildings and equipment.

Soil, scale and encrustations yield to a hydraulic jet cleaner that shoots a high velocity stream up to 50 ft. Mixing chamber of venturi injector uses ordinary plant steam and water to generate a cleansing jet.

With plant steam pressure of 5-150 psi. and water pressure from 10-40 psi., unit produces jet pressures 4 to 20 times inlet steam pressure. Detergent or solvent may be mixed with the jet in amounts up to 25% of volume, may be drawn automatically from any drum or tank without an auxiliary pump.

Unit is supplied with 50 ft. of neoprene hose, a cleaning lance with handle, and a nozzle with interchangeable disks. Stationary or portable versions mounted on 50-gal. detergent tanks are available. — **Sellers Injection Corp., Philadelphia.** **78B**

Gate valve

Port valve with nonrising stem is sized for manifold service.

Known as G-6, a new port valve is smaller in height and width than conventional port valves, thus making it particularly suited for manifold service, where compactness is a virtue, and full-opening valves may not be needed.

G-6 valve has metal inner seat rings backed by O-rings. With each operation, the metal seats strip foreign matter from the gate while the O-rings clean and polish both faces. Seating surfaces, always in contact with the gate, are isolated from fluid erosion and corrosion, require no lubrication.

MORE NEW EQUIPMENT
(Continued on page 158)

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U.S.I. CHEMICAL NEWS

October ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1960

National Distillers Joins Shell International in Polyolefin Venture Abroad

A joint company has been formed by Shell International Chemical Company Ltd., London, and U.S.I.'s parent company, National Distillers, to develop plans for production and marketing of polyolefin film and packaging materials outside the U.S. and Canada. The new company operates from London.

National Distillers is one of the world's largest producers of polyethylene and owns the Kordite Company—a leading manufacturer in the U.S. of plastic film and packaging. It has recently set up a company in Switzerland to cover sales and development of polyethylene.

New Direct Halogenation Process Converts Impure Metal to Purified Halide

A safe and commercially adaptable process for the direct halogenation of crude metals—to obtain the corresponding halide substantially free of certain undesirable metal impurities—is covered in a patent recently issued to U.S.I.'s parent company, National Distillers. Metal halides which can be prepared by this process are those of the reactive metals such as titanium, zirconium, hafnium, columbium and tantalum.

As described in the patent, an impure feed such as scrap zirconium is safely reacted with a halogen gas by diluting the latter with an explosion-preventing proportion of helium, argon or neon. The reaction is carried out at 450°-900°C until 50-90% of the feed has been reacted. A metal halide is recovered which is considerably lower in metal impurity content than the original scrap feed. A typical analysis of $ZrCl_4$ prepared by this process is given in the following table:

COMPARATIVE METAL IMPURITY CONTENTS—METAL FEED VERSUS HALIDE PRODUCT

Metal Impurity	Low Hafnium Zirconium Scrap Feed*	$ZrCl_4$ Product*
Al	65	94
Cd	<0.5	0.8
Cr	700	35
Fe	970	140
Mn	23	5
Ni	255	15
Pb	85	20
Sn	1.6%	188
Ti	20	20
U	10	10
W	20	20

*Values in ppm based on zirconium unless otherwise stated

Ammonia Production, Storage Capacity Expanded by U.S.I.

Refrigerated, Non-Pressurized Storage Tank to be Installed

Ammonia production capacity has been increased by 17%, and anhydrous ammonia storage capacity will soon be expanded by U.S.I. at its Tuscola, Illinois, plant. The plant is already operating at the expanded rate of 70,000 tons per year (up from 60,000 tons) and a new 6,000-ton storage facility is expected to be in full service by the end of the year.

This increased production and storage capacity are needed to assure rapid delivery to U.S.I.'s ammonia, aqua ammonia and nitrogen solutions customers, especially during the heavy seasonal demand in early spring. Because of the plant's location in Central Illinois, heart of the Midwestern fertilizer industry, most of its output is used as a raw material in this highly seasonal business. Other applications for U.S.I. ammonia include chemical processing, refrigeration and miscellaneous industrial uses.

Storage Tank Uses New Principle

The new 6,000-ton storage tank will use the relatively new principle of storing refrigerated ammonia at atmospheric pressure, rather than storing in pressurized tanks at moderate temperatures. The storage vessel consists of an inner tank, 88 feet in diameter and 56 feet high, separated from an outer tank by 2½ feet of insulation. Liquid ammonia is stored in the tank at a temperature of about −28°F. and this low temperature is maintained by evaporation of ammonia from the surface.

The evaporated ammonia is recompressed, condensed and returned to the tank. It can also be used as feed stock for the adjoining ammonium nitrate plant.

Polyethylene — Aggregate Forms New Paving Material

A new paving material compounded of pigmented polyethylene and aggregate promises to bring color-coding of roads and runways closer to reality. It can be mixed and applied (in a one-inch layer) using conventional machinery and methods. Brilliant white test curbing, shown being installed in the photo above, defines road boundaries. Other possible uses include multi-colored home driveways, tennis courts, sidewalks, swimming pools.

New TVA Process Uses Wet-Process Phosphoric to Make Diammonium Phosphate

TVA engineers are developing a new process to make granular diammonium phosphate fertilizer. It is reported that the method can use low-cost wet-process phosphoric acid without a purification step.

By taking advantage of chemical heat in the reaction of acid and ammonia, recycle rates and drying requirements are reduced below those of some competitive processes, according to TVA. Grade of product depends on purity of phosphoric acid available, and ranges up to 21-53-0. The process is being adapted to production of various grades, some containing potash.

TVA claims that its ammoniator is the key equipment in the process. Wet-process phosphoric acid, such as that made by U.S.I. at Tuscola, Illinois, is partially

MORE

New Type of Carbon Black Obtained from Burning Hydrocarbons in Chlorine

Researchers have obtained high yields of carbon blacks containing chemically bonded chlorine, by burning various hydrocarbons in the halogen gas rather than in oxygen. Such chlorocarbon blacks may have commercial use in rubber and plastics compounding, according to a recent report.

In the study, methane, propane, ethylene and natural gas were burned with submaximal amounts of chlorine to yield carbon black as a major product. By

MORE

CONTINUED

TVA Process

preneutralized in a tank. Then the ammoniation to diammonium phosphate is completed in the ammoniator-granulator drum. Excess ammonia must be fed to the drum to produce diammonium phosphate. Therefore, a scrubber is required to recover ammonia from exhaust gases. Phosphoric acid is fed to the scrubber to absorb ammonia, and the solution is fed to the preneutralizer. A recycle ratio of about 3:1 is required for control of granulation. Physical properties of the closely sized granular product are said to be excellent.

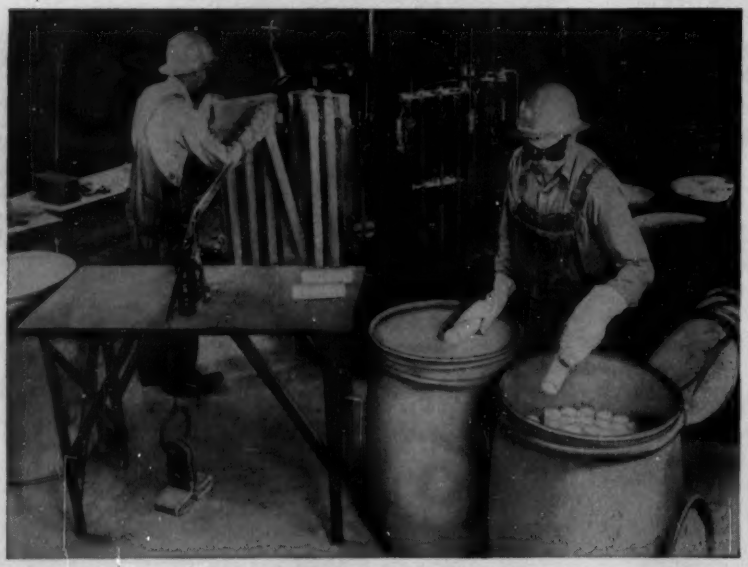
CONTINUED

Chlorocarbon Blacks

contrast, carbon black is only a by-product when these hydrocarbons are burned with oxygen. The quantity of carbon produced in the chlorine-hydrocarbon flames seems to be directly proportional to the chlorine-hydrocarbon ratio. It also seems to depend on the hydrocarbon used, and is greatest for methane.

These carbon blacks can contain as much as 45% chlorine. The halogen appears to be bonded to the carbon chemically, researchers report, since all attempts to remove it have left at least 10% chlorine.

No Oil for Sodium Bricks



Sodium packed under kerosene? Perhaps in the laboratory but not in industry, as you can see from this photo of the cutting and packing operations at U.S.I.'s metallic sodium plant in Ashtabula, Ohio. Every year, many tons of sodium are molded into bricks and packed *dry* in steel drums. An airtight seal is maintained during storage and shipment.

All phases of sodium handling are discussed in the latest edition of U.S.I.'s brochure "Handling Metallic Sodium on a Plant Scale". For your copy, address Technical Literature Department, U.S.I. Chemical News, 99 Park Avenue, New York 16, New York.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

Chlorine safety data sheet is now being sold by MCA for nominal price. Covers properties, hazards and their engineering control, employee safety, emergency measures, container handling, waste disposal, medical management. **No. 1640**

New group of urethane elastomers now offered for use where abrasion resistance is essential. Claimed more rugged than manganese steel and other metals. Suggested for chute linings, pipeline crawler wheels, scrapers, etc. **No. 1641**

Temperature-indicating crayons and paints now on market are said to check temperatures of hot surfaces by completely changing color. Series of products cover range from 104°F. to 2,462°F. Claimed easy to apply and remove. **No. 1642**

Sodium peroxide is covered in new data sheet giving specifications, typical analysis, properties, shipping data and uses. Technical service is offered on handling and use in pulp and paper, textile and other fields. **No. 1643**

New laboratory oven is said to give highest temperature, combined with vacuum, now available. Can heat from room temperature to 500°F. in one hour, in 11-inch diameter by 12-inch deep vacuum chamber. **No. 1644**

Dry sulfamic acid product—with built-in pH color indicator, corrosion inhibitors, anti-foams, wetting agents—can now be obtained for removal of lime scale deposits from evaporative condensers and cooling tower systems. **No. 1645**

Polyethylene waste and drainage system described in new engineering and parts catalog now available. Said to be complete, permanent, corrosion-resistant. Includes sinks, traps, pipe and fittings, adapters, other equipment. **No. 1646**

Concise conversion tables and circular slide rule, now offered for chemical engineers, is shirt-pocket size. Includes slide rule, table of elements, temperature conversion chart, conversion factors, useful constants and data. **No. 1647**

***m*-Sulfobenzoic acid**—new intermediate for dyes, colors, color developers and couplers, surfactants, textile treating agents, flavors, drugs, preservatives, dehydrating agents—is subject of data sheet recently released. **No. 1648**

Fallout is subject of new book which can now be purchased. Book covers bomb types, meteorological dispersion and persistence of fallout, effects of radiation, radiation sickness, biological effects, nuclear war, civil defense. **No. 1649**

PRODUCTS OF U.S.I.

Heavy Chemicals: Anhydrous Ammonia, Ammonium Nitrate, Nitric Acid, Nitrogen Fertilizer Solutions, Phosphatic Fertilizer Solution, Sulfuric Acid, Caustic Soda, Chlorine, Metallic Sodium, Sodium Peroxide.

Organic Solvents and Intermediates: Normal Butyl Alcohol, Amyl Alcohol, Fusel Oil, Ethyl Acetate, Normal Butyl Acetate, Diethyl Carbonate, DIATOL®, Diethyl Oxalate, Ethyl Ether, Acetone, Acetoacetanilide, Acetoacet-Ortho-Chloranilide, Acetoacet-Ortho-Toluidide, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Sodium Oxalacetate, Sodium Ethylate, Urethan U.S.P. (Ethyl Carbamate), Riboflavin U.S.P.

Pharmaceutical Products: DL-Methionine, N-Acetyl-DL-Methionine, Urethan USP, Intermediates.

Ethyl Alcohol: Pure and all denatured formulas; Anhydrous and Regular Proprietary Denatured Alcohol Solvents SOLOX®, FILMEX®, ANSOL®M, ANSOL PR

PETROTHENE® . . . Polyethylene Resins

MICROTHENE . . .Finely Divided Polyethylene Resin.

Animal Feed Products: DL-Methionine, MOREA® Premix (to authorized mixer-distributors).

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Recognizing that no single type filter press will satisfy all requirements, Sperry makes available the broadest combinations of design features to help you achieve maximum efficiency and economy.

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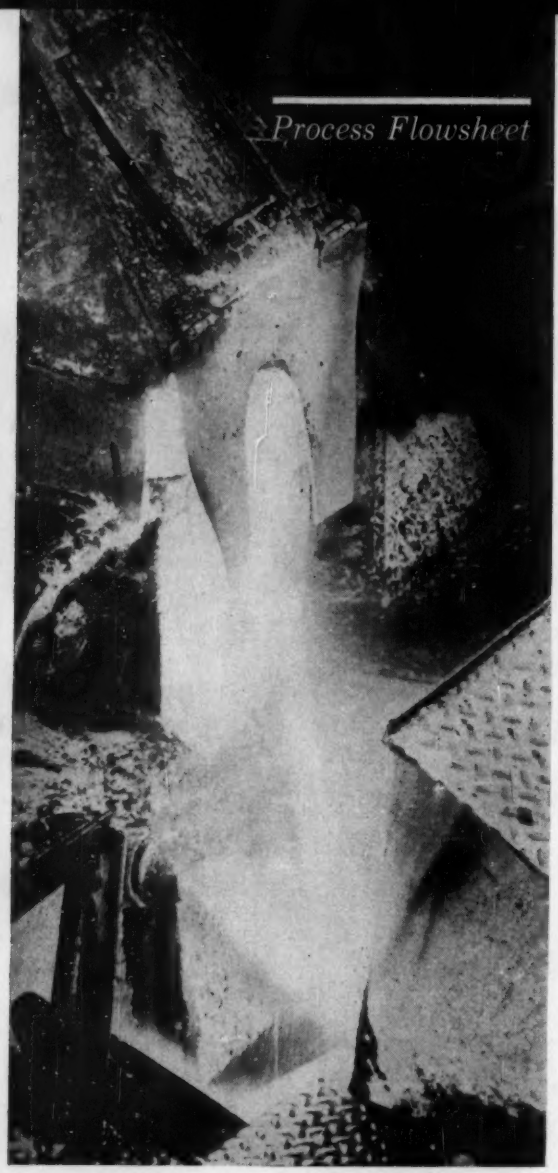
Process Flowsheet



Molten beryl ore leaves arc furnace, goes to quench tank during early step in making beryllium ingots.

Pure Beryllium Via the Fluoride Process

Brush Beryllium Co. melds smart chemistry, careful engineering in winning the costly metal from ore.

N. P. CHOPEY
Assistant Editor

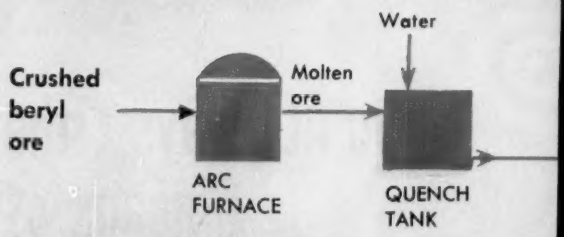
Beryllium's star is still on the rise. Latest evidence: an announcement that Brush Beryllium Co., a leader in the field, is doubling capacity to make vacuum-cast billets of the exotic light metal at its Elmore, Ohio, plant. The $6-million expansion will give Brush a new production capability of about 24,000 lb./month.

Beryllium first became industrially noteworthy in 1926 with the discovery that, though costly and hard to machine by itself, it was a valuable alloying element for copper. But the greyish, brittle metal has really come into its own just in the past few years, in the area of nuclear technology. A good moderator or reflector for thermal neutrons, it now has full status as a nuclear material of construction.

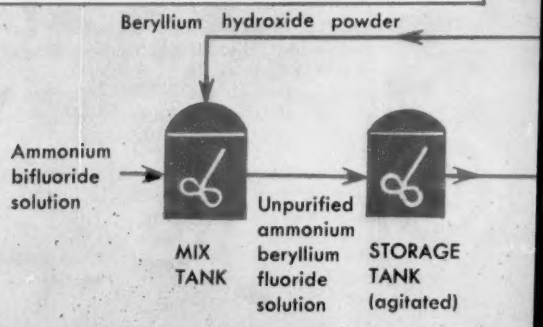
Also, beryllium shows promise of branching into aeronautics. If fabrication problems can be completely solved, the metal is likely to show up in aircraft, missile applications.

▸ **Properties, Good and Bad**—Usefulness of beryl-

Processing Beryl Ore to...



A successful beryllium operation must discard virtually all the nonberyllium content of the ore while taking care not to throw away any of the expensive metal. Brush Beryllium's plant removes nonberyllium constituents through the streams labeled in boxes, at right.



Processing Beryllium Hydroxide to...

Unfold Flowsheet

lium for aeronautics stems largely from an unusual combination of features: the metal is very light (specific gravity of beryllium is 1.8, aluminum's is 2.7) yet has a high melting point of 2,341 F. It also boasts high thermal conductivity, heat capacity and stiffness, plus the nuclear features cited above.

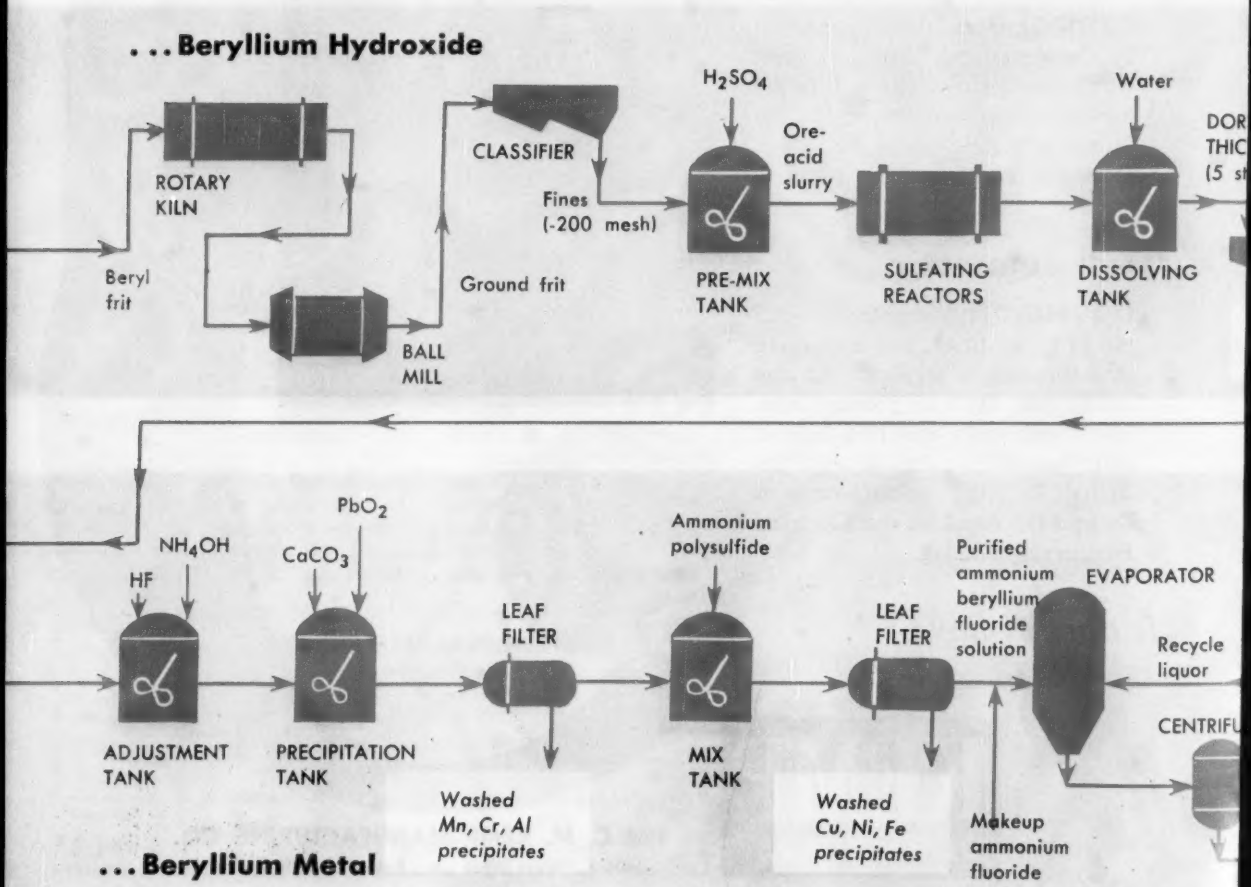
But, beryllium is also expensive, hard to fabricate and toxic. Current cost is about $50-100/lb. in lump form, and much higher in more useful shapes because of the difficulty in machining it. Properties that make fabrication or machining a problem include brittleness and low ductility.

Beryllium and its compounds are ranked among the most toxic of materials. Hazards stem from both inhalation and contact with the skin, and plants such as Brush's Elmore facility must make much use of remote-controlled operation in making metal from the ore.

Too, the metal is chemically reactive when hot. Therefore, it cannot be commercially extracted from ore by ordinary smelting methods. Instead, the ore usually is first treated chemically to make beryllium oxide or hydroxide. Next step is conversion to the anhydrous chloride or fluoride; then, this halide is reduced to the metal.

► **Purity**—Nuclear beryllium must be very pure, with low levels not only for contaminants that can affect mechanical properties but also for elements that are high neutron absorbers or that form radioactive, long-halflife isotopes after irradiation. A particularly pure grade, which Brush has made for the U.K. Atomic Energy Authority, has specifications that include less than 500 ppm. Al, 700 ppm. C, 500 ppm. Fe, 150 ppm. Mg, 50 ppm. Mn, 100 ppm. Ni and 300 ppm. Si.

Bulk of the nonberyllium constituents of ore are removed during processing to the oxide or hydroxide. Further purification takes place while the beryllium is in halide form and the rest occurs during reduction and casting. Because of the costliness of the metal, the beryllium producer must



be careful not to discard beryllium-bearing material while he is removing impurities.

▶ **Two Halide Routes**—After the oxide or hydroxide is produced, it can be converted to either (1) a fluoride, which is subsequently reduced in a furnace by magnesium, or (2) a chloride, for subsequent reduction by electrolysis. Brush uses the former alternate at Elmore, thus refutes opinions previously held in the industry that the fluoride route could not make high-purity beryllium.

▶ **Ore to Hydroxide**—Brush starts with beryl ore, which in pure form is a beryllium-aluminum silicate. This ore is the standard raw material for beryllium production today.

At Elmore, crushed ore is melted in a 1,500-kw. carbon-lined arc furnace, then quenched with water. This treatment destroys beryl's crystal form, thereby making the mineral more reactive.

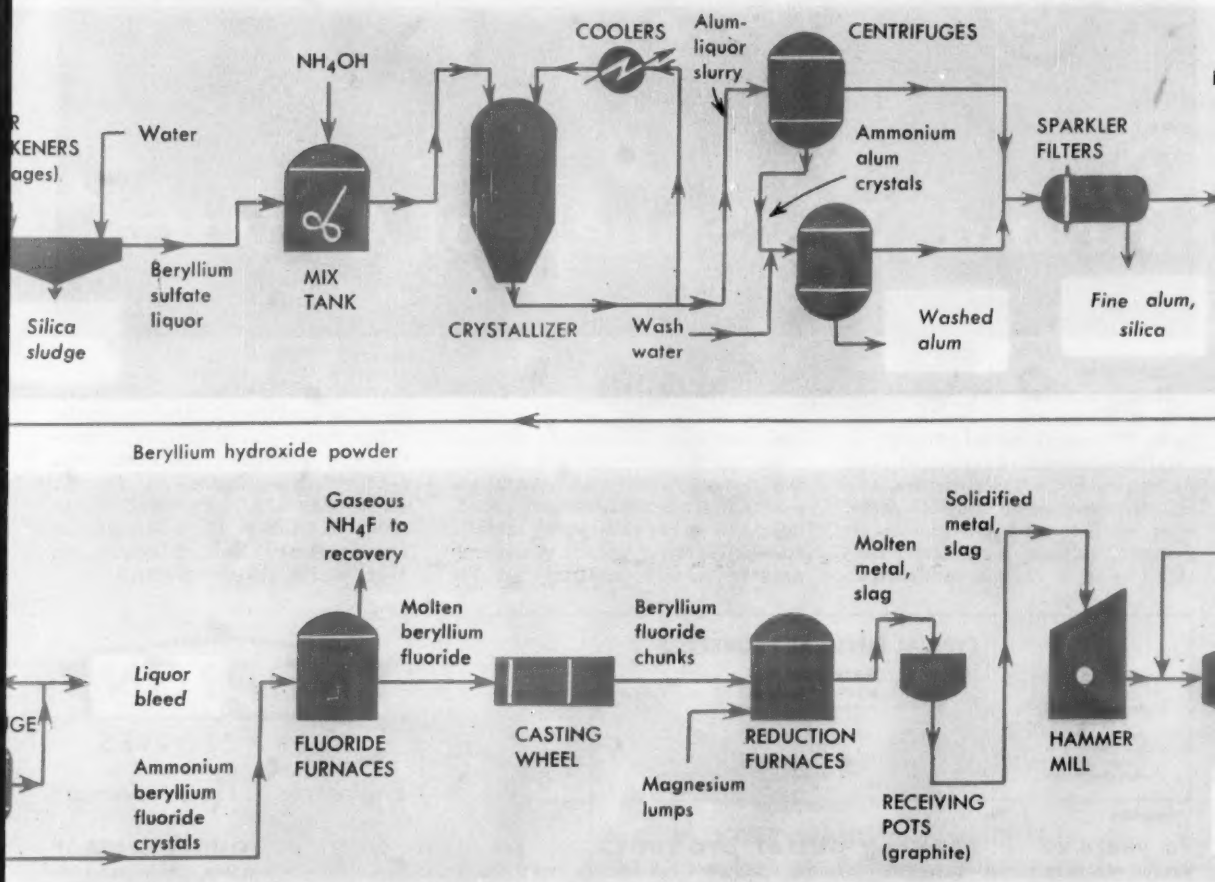
Quenched material, known as frit, is heated in a rotary kiln to further improve reactivity, then dry milled and classified. Minus-200-mesh fines are combined with 93% sulfuric acid and the slurry goes to preheated sulfating reactors similar in construction to rod-mill pulverizers.

Sulfating reaction, around 575 F., converts beryllium oxide to water-soluble beryllium sulfate and renders the ore's silica content insoluble. The silica is then removed as sludge by leaching in a five-stage Dorr-thickener arrangement.

Supernatant liquor from the thickeners is treated with ammonium hydroxide and cooled, causing some aluminum to drop out as ammonium alum crystals. Most of the alum is removed in a Bird centrifugal, and the crystals are washed to avoid beryllium loss. Fine alum and residual silica are then taken out in a sparkler filter.

The clear liquid goes to an agitated tank called a beryllator, where sodium hydroxide is added. Undisclosed chelating agents are also added here to keep heavy metal impurities, such as iron, in solution when beryllium hydroxide is precipitated.

Beryllium leaves this vessel in the form of



sodium beryllate. This is converted to beryllium hydroxide in a hydrolyzer at about 203 F.; the hydroxide precipitates and is separated in a centrifuge and a Dorr thickener. This step completes the first phase of the over-all process.

►**The Fluoride**—Conversion of the hydroxide to metal starts with preparation of ammonium beryllium fluoride, by slurrying the hydroxide with ammonium bifluoride solution. Then, hydrofluoric acid and ammonium hydroxide are added to balance the amounts of ammonium, beryllium and fluoride ions in solution.

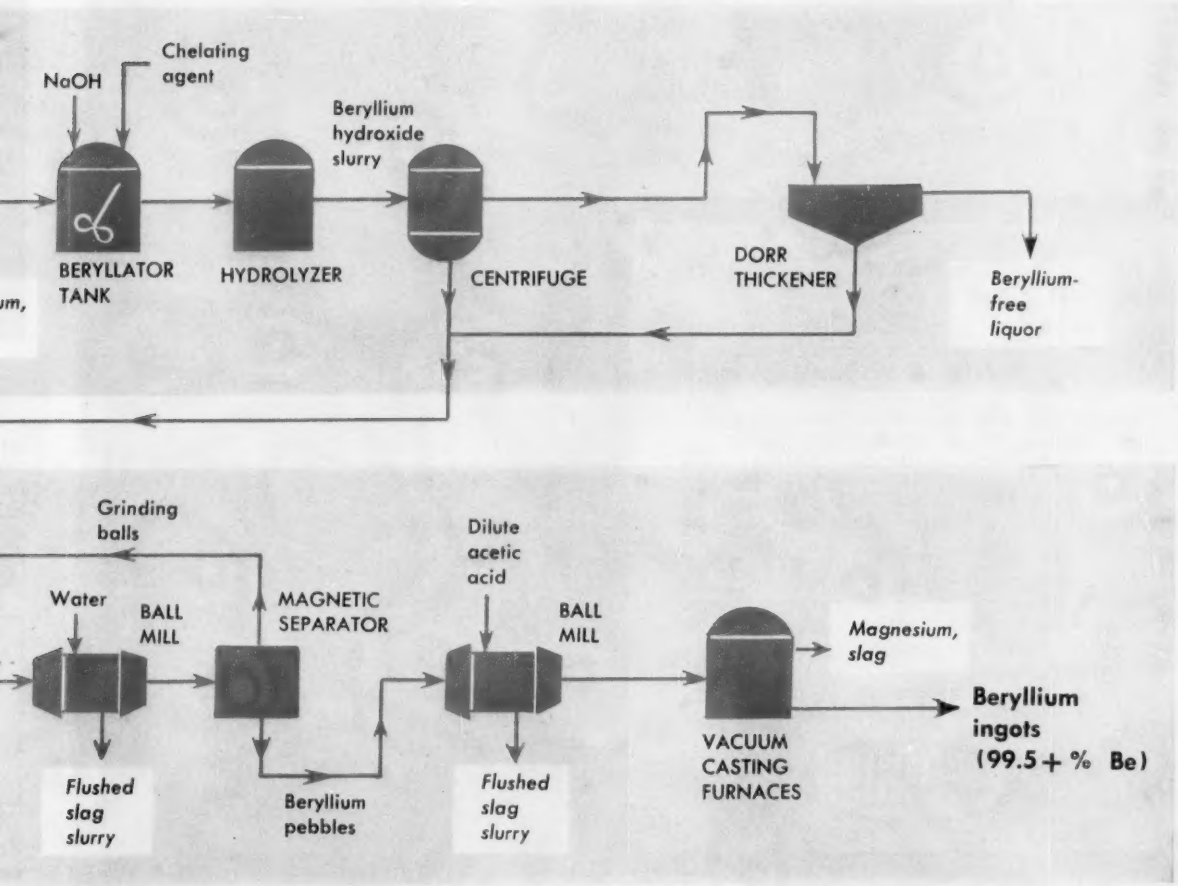
This balancing causes a complex ion to form, which dissociates so slightly that the beryllium does not drop out during subsequent precipitation of impurities. Formation of this ion is a key factor in successful purification.

Impurities removed by precipitation include Mn, Cr, Al, Cu, Ni and ferrous Fe. Precipitating agents are calcium carbonate, lead peroxide and ammonium polysulfide, as well as free ammonia produced by ammonium-fluoride decomposition during the purification. Precipitates, removed in leaf filters, are thoroughly washed before disposal.

Pure solution goes next to continuous vacuum-salting evaporation at 122 F., producing ammonium beryllium fluoride crystals. Crystals are separated, then decomposed to ammonium fluoride and beryllium fluoride at about 1,650 F. in an induction furnace. The ammonium fluoride leaves overhead, is absorbed in water, acidified with HF and recycled for mixing with beryllium hydroxide.

►**Finishing Up**—Molten beryllium fluoride is cast into chunks, then reduced with magnesium in furnaces that operate at about 2,370 F. Molten beryllium and slag mixture from these furnaces is solidified in graphite pots, then crushed in a hammer mill and leached in ball mills.

Last step is vacuum-casting, in furnaces that can hold about 75-80 lb. metal. The furnaces remove residual magnesium and slag, yield finished ingots. Final purity: over 99.5% beryllium.



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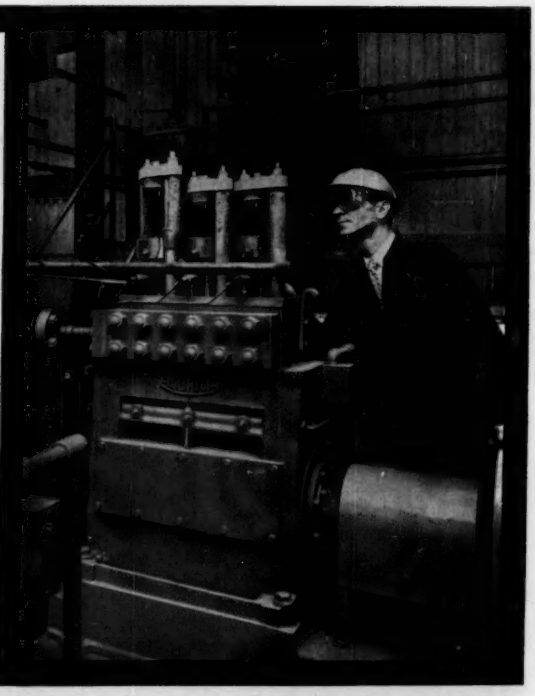

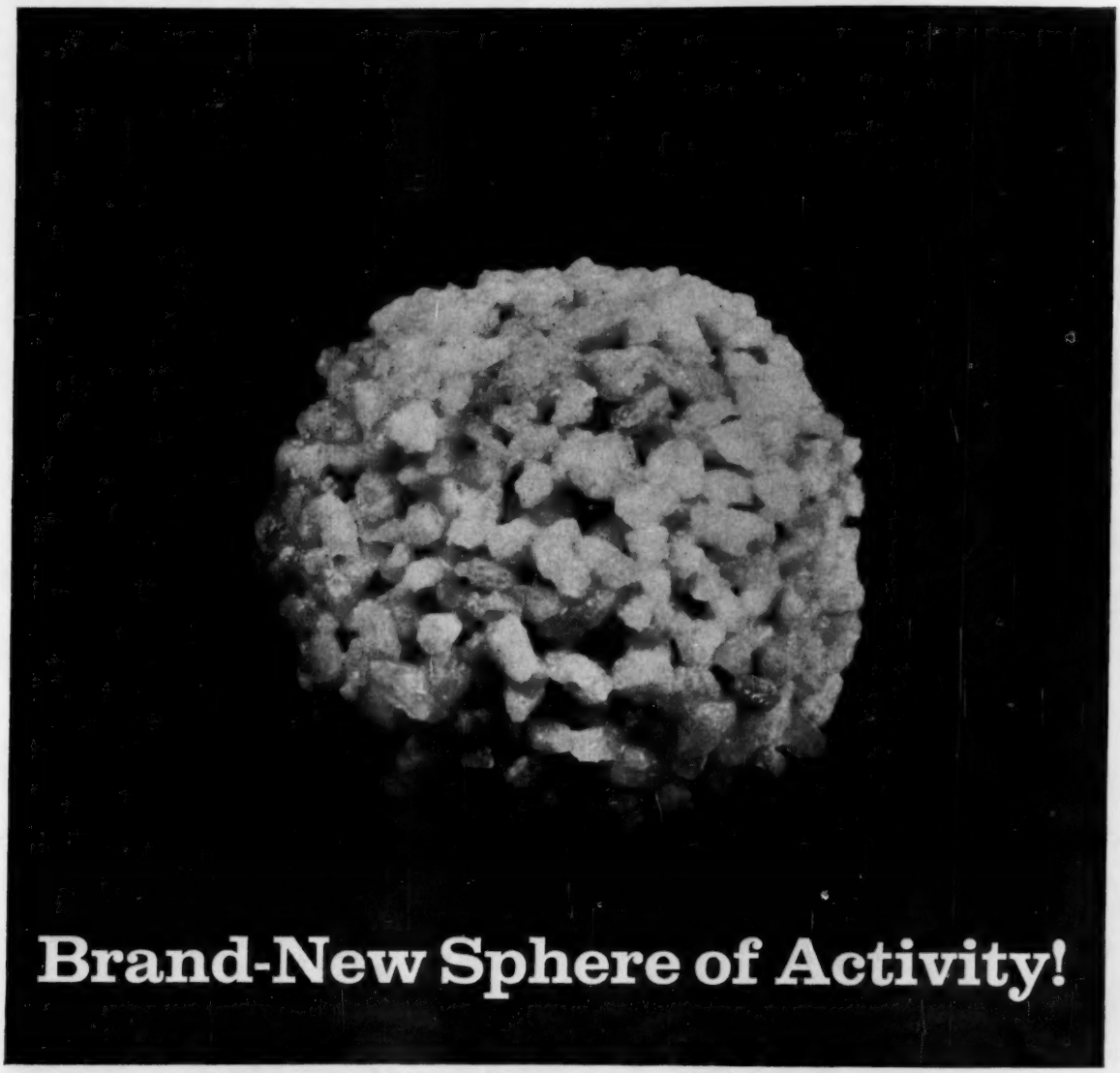

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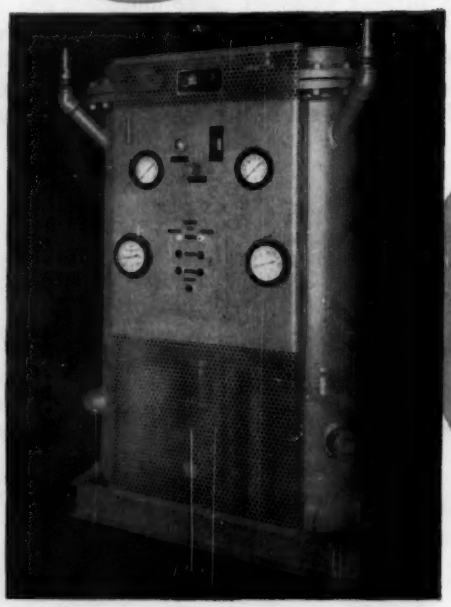

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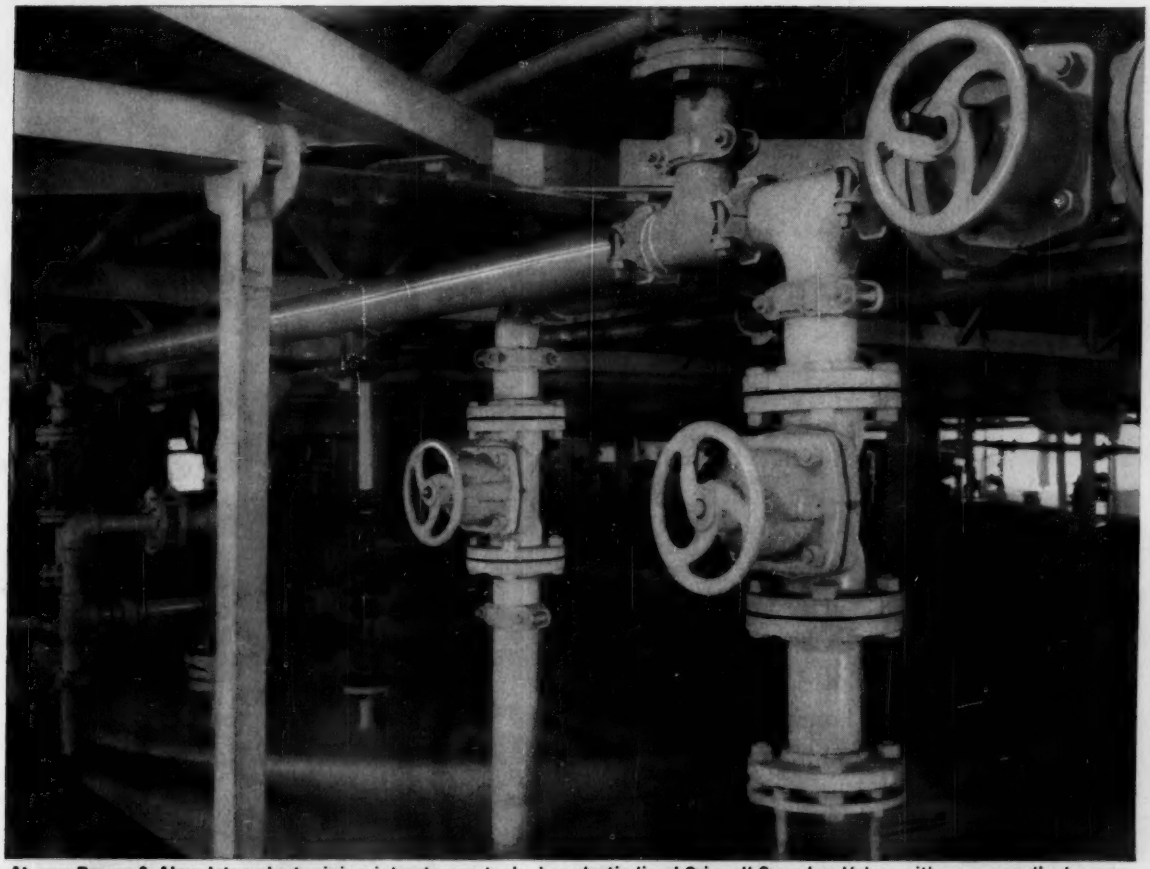

At new Dewey & Almy latex plant, piping into storage tanks has plastic-lined Grinnell-Saunders Valves with neoprene diaphragms.

At Dewey & Almy plant...

Grinnell-Saunders Diaphragm Valves guard against plugging, corrosion, contamination

The new Owensboro, Kentucky plant of Dewey and Almy Chemical Division, W. R. Grace & Co., makes polyvinyl acetate emulsions and butadiene-styrene co-polymers for adhesives, paper coatings, emulsion paints and other products.

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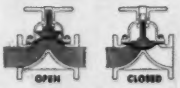

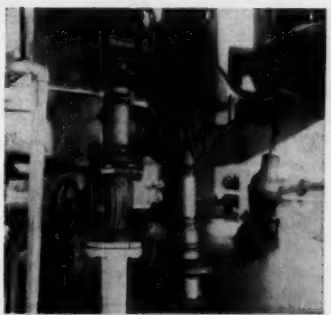

Grinnell-Saunders Valves with stainless steel bodies and teflon diaphragms were specified for the reflex lines of this co-polymer reactor.

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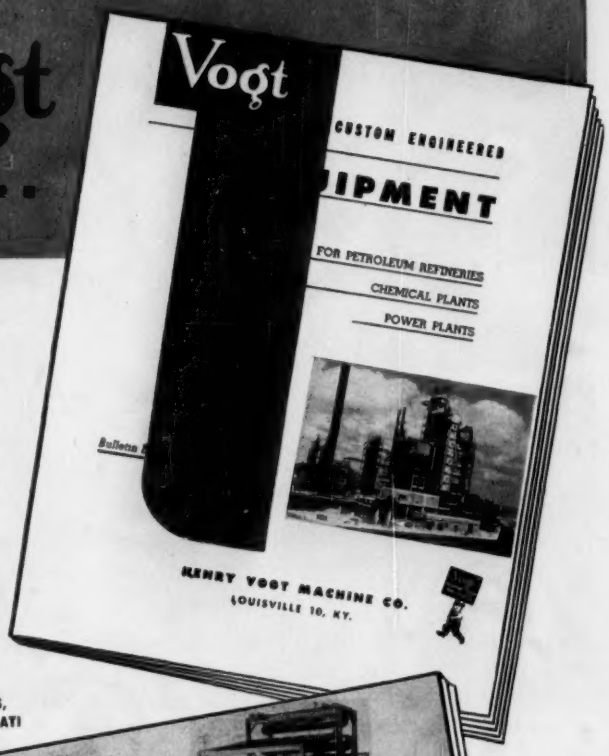

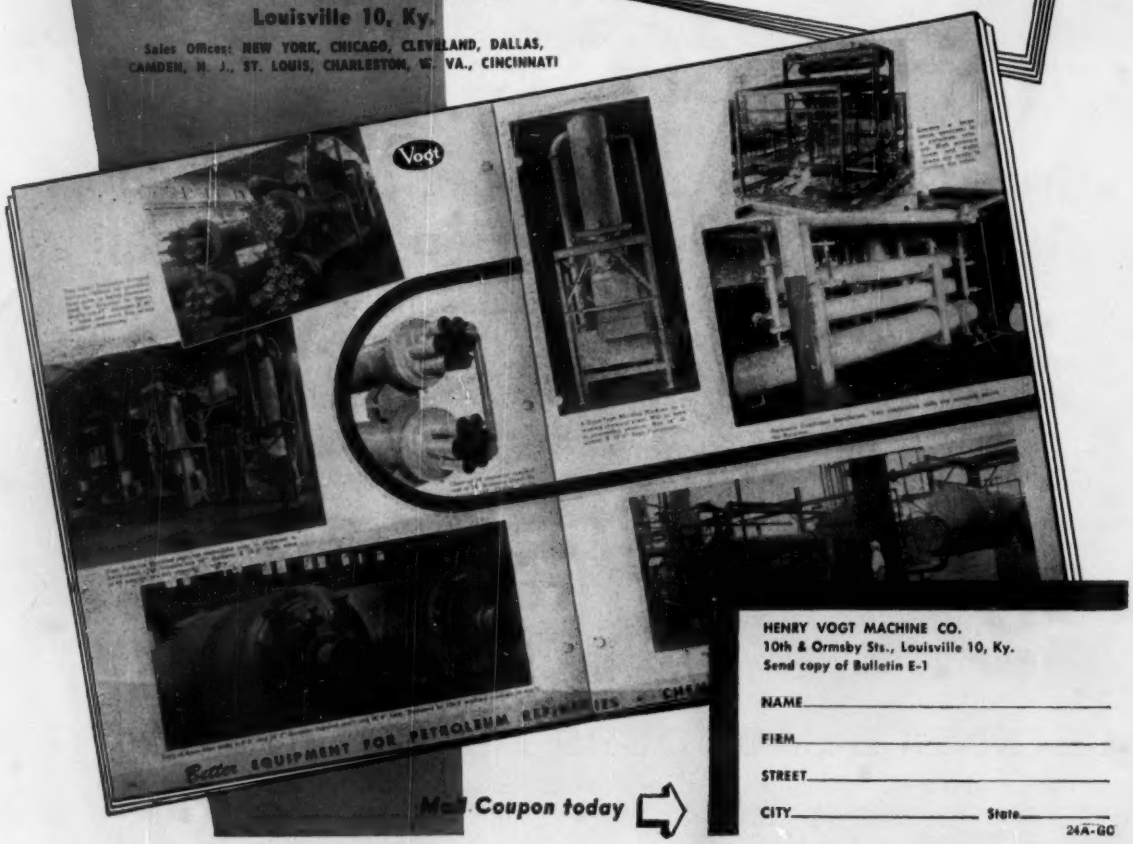

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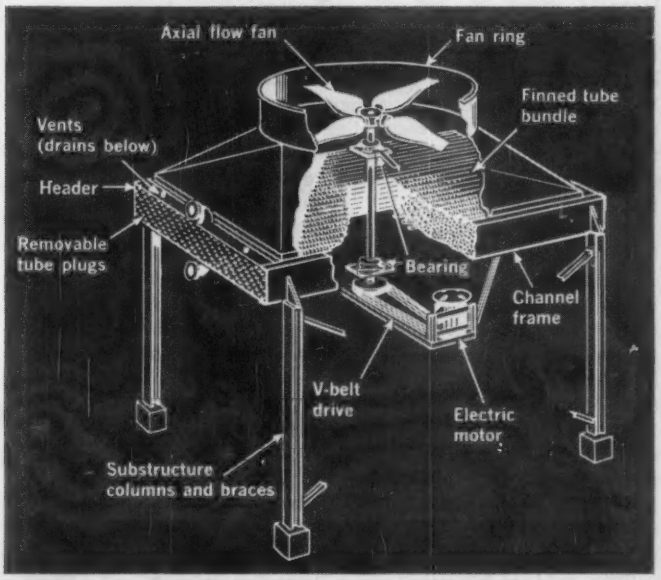


Illustrations courtesy of Hudson Engineering Corp.

In the last two or three years there has been a great increase in interest in the air-cooled heat exchanger. This article represents a distillation of the experience of many people in designing exchangers of this type.

Design of Air Cooled Heat Exchangers

FRANK L. RUBIN, *Downingtown Iron Works, Inc.*

For many years, atmospheric air has been used to cool process fluids in areas of water scarcity. However, interest in the air cooled heat exchanger is much more recent in regions where the available supplies of cooling water are unlimited. As recently as the 1958 winter national meeting of the American Institute of Chemical Engineers, there was a symposium (Refs. 3, 4, 5, 6, 7, 9, 10, 12) that was the first to bring widespread American attention to this method of cooling. Other important articles include Refs. 1, 2, 8 and 11.

In the air cooled heat exchanger, ambient air is forced or induced by a fan to flow across a bank of externally finned tubes. A typical air cooler has a horizontal section containing finned tubes, a steel supporting structure with plenum chambers and fan ring, an axial flow fan and drive assembly and, finally, miscellaneous accessories such as louvers, fan guards, fencing and hail screens. In addition to the cooler with horizontal tubes, vertical and sloped tubes have been used in condensing service.

Finned Tube Elements

The most commonly used tube size is 1 in. O.D. Fin heights vary from $\frac{7}{16}$ to $\frac{5}{8}$ in., with fins spaced at from 7 to 11 per lineal inch. Tubes are arranged on 2 to $2\frac{1}{2}$-in. triangular pitch. Ratio of extended surface to bare-tube outside surface, ranges from 7 to 20; however, many designers prefer to use the ratio of extended surface to *internal* surface, which ranges from 8 to 30. Tubes of $1\frac{1}{4}$ in. O.D. have been used for flue gas and viscous oil service. All of the factors of tube size, fin height and fin spacing can be varied further.

Standard tube lengths range from 8, through 10, 12, 20, and 24 ft., up to 30 ft., the last two lengths being common in petroleum refineries. Bundle depth varies from 3 to 30 rows of tubes, with 8 rows per bundle used as a standard. Bundles of this nature may be stacked.

Individual bundle depth may be limited in types of service with a high temperature difference per pass. In some cases, horizontally split headers may be required to accommodate differential tube expansion.

Aluminum is considered the most economical fin material for process design temperatures up to 750 F. (This criterion generally limits the aluminum fin-base temperature to less than 450 F.) Bare steel tubes have been used for bottoms coolers operating at low heat

transfer rates in various large-scale operations.

The least expensive finned tubing has the aluminum fins mechanically wrapped under tension onto the knurled outside surface of the tubes. The fin ends are held firmly to the tube by soldering or by a collar to prevent loosening or unraveling of the fins. Such tubing is adequate where vibration can be minimized and for process-side design temperatures of 250 F. or less.

The often used bimetallic tubing consists of an inner tube of material required to meet the process corrosive conditions, within an aluminum outer tube from which most of the metal has been cold extruded into high fins. During the process, a complete mechanical bond is formed between the inner liner tube and the outer finned tube. Process-side design temperature is limited to 550 F.

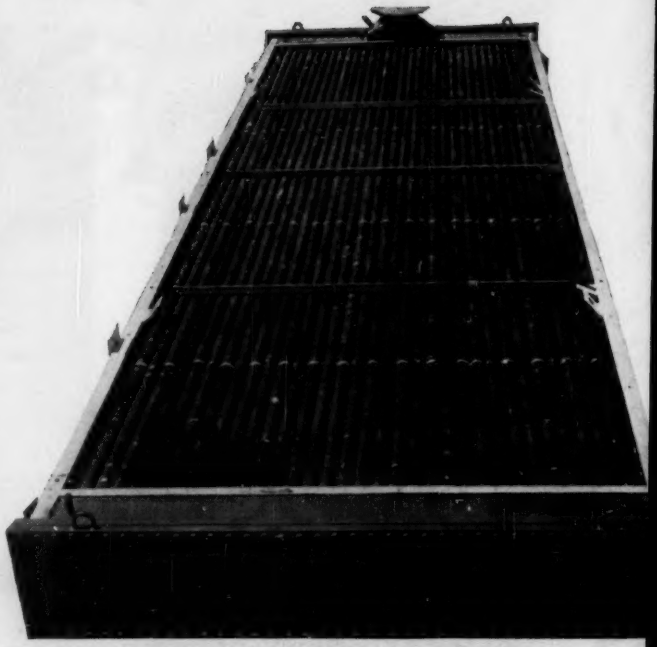
Another type of tube has the aluminum fins mechanically wrapped under tension and inserted into a groove about 0.008 in. deep in the tube wall. This type is adequate for service up to 750 F. Recently developed tubing has a fin-insertion depth of 0.050, in., which increases fin strength.

Tube ends are left bare to permit their insertion into appropriate holes in the headers. Tube ends are usually roller expanded into these tube holes. The headers are often designed with plugged tube access holes opposite the ends of each tube.

A complete tube bundle consists of headers, finned tubes, structural steel side channels, plus supports. Such a bundle requires tube spacers to prevent meshing or deformation of the fins; tube supports beneath the bottom row of tubes to prevent sagging of the bundle; and "keepers" placed across the top of the tube bundle to hold the tubes in position.

Tube bundles are generally designed to be rigid and self-contained and are mounted so that they can expand independently of the supporting structure.

Face area of a tube bundle is its length times width. The net free area for air flow through each tube row is about 50% of the face area of the bundle. The face velocity of air through the bundle generally ranges from 300 to 700 ft./min. The standard air face velocity (FV) is defined as the velocity in ft./min. of standard air passing through the bundle. Standard air is defined as dry air at 70 F. and 29.92 in. Hg pressure, having a density of 0.075 lb./cu. ft. and a specific heat of 0.24 Btu./(lb.) (°F.).



Finned tubes, commonly the 1-in. O.D. size, and in lengths from 8 to 30 ft., are assembled into rigid, self-contained bundles with the aid of headers and structural steel side channels.

Fans and Drivers

Axial flow fans are large-volume, low-pressure devices. A fan for this service must operate at reasonably high efficiency to minimize power consumption. Coolers require a relatively large volume displacement at a static pressure of 0.25 to 1.0 in. w.g. Fan diameters are selected to give velocity pressures of about 0.1 in. w.g. The total fan efficiency is about 65% while the drive itself usually has a minimum mechanical efficiency of 95%.

Fans usually have four or six blades and their diameter is generally equal to or slightly less than the bundle width (although it may be no more than 60-80% of bundle width). Where tube length and bundle width are approximately equal, one fan may be used. When the length is two to three times the bundle width, an appropriate number of fans in parallel is required.

Noise level of a fan is directly related to the tip speed. Unfortunately, at the tip speeds required for economical, efficient performance, a large amount of noise is produced. Therefore, it is necessary to consider the location of an air cooler in setting the maximum speed.

Hartzell Propeller Fan Co. has recommended (Engineering Article V, Feb. 1957) that maximum fan tip speeds shown below should be used to limit fan noise:

Maximum Fan Tip Speeds, Ft./Min.

Neighborhood	Induced Draft	Forced Draft
Industrial	13,000	11,000
Semi-residential	11,500	10,000
Residential	10,000	9,000

Note: Fan tip speed = $\pi D \times$ rpm. D = fan diam., ft.

Note that small units with direct-drive, fixed-pitch blades of 4 to 5 ft. diameter, often operate with speeds 50 to 100% higher than the values shown in the table.

Axial flow fans are inherently devices for moving a consistent volume of air when blade setting and rotational speed are constant. Variation in the amount of air flow can be obtained by adjusting the blade angle of the fan and the speed of rotation. The blade angle can be either permanently fixed, hand-adjustable or

automatically adjustable. Air delivery and horsepower are a direct function of blade pitch angle.

Fan relationships between rotational speed and other pertinent quantities are as follows:

Volume delivered $\propto$ rpm.

Static pressure developed $\propto$ $(\text{rpm.})^2$

Horsepower required $\propto$ $(\text{rpm.})^3$

Fan mounting should provide a minimum of $\frac{1}{2}$ to $\frac{3}{4}$ fan diameter between the fan and the ground on a forced-draft heat exchanger; and $\frac{1}{2}$ diameter between tubes and fan on an induced-draft cooler.

At a distance of 50 ft. from the fan, the noise level rating of typical fans ranges from 71 to 88 decibels. Changes in the fan speed affect the noise level as follows:

Speed Ratio	Decibels Change
1.00	0
1.25	4.8
1.50	8.6
1.75	12 (May be erratic)
2.00	15 (May be erratic)

When the fan manufacturer specifies the noise level at a particular speed, this table can be used to estimate noise level at other speeds. If the speed is higher, add the given decibel change. Subtract it from the rated noise value if the speed is lower.

Fan blades can be made of aluminum, molded plastic, laminated plastic, carbon steel, stainless steel and Monel. Aluminum blades offer advantages but it should be noted that failure in service can result in a large piece of blade breaking free and flying off rapidly through centrifugal action.

Laminated plastic blades can be made so as not to be "notch-conscious." Hence, if a blade is hit by some object, and a piece taken out, the crack or notch will not progress as it will in metal. The laminate tends to dampen vibration since it has a very low resonant amplification factor. The resonant amplification factor of such a material may be no more than 20% of that of aluminum or stainless steel blades. This means that if a blade happens to be operating at a resonant frequency, the forces will be amplified only 20% as much as in a metal blade.

In general, solid plastic blades are similar to laminated plastic blades. They are slightly more flexible and their maximum operating temperature is somewhat lower. The blades of an induced-draft fan may operate at too high a temperature for plastic.

Fan Drivers—Steam turbines or electric motors are the most commonly used drivers. These connect with gears or V-belts. Also in use are gas engines connected through gears, and hydraulic motors either direct-connected or connected through gears. Fans have also been driven from other machinery such as compressors, using a V-belt takeoff from the flywheel to a jack shaft, thence through a gear or belt drive to the fan. Direct motor drive is generally limited to small-diameter fans.

Gears are subject to severe service and are generally of the spiral-bevel type, with a service factor of 1.5, in accordance with American Gear Manufacturers' Assn. Standard 430.02.

V-belt drive assemblies are commonly used with fans of 10-ft. diameter and less, and motors of 20 hp. and less. For larger fans, and for motor powers of 25 hp. and more, right-angle gear drives are preferable. The same is true where the driver is a steam turbine.

Fan Ring and Plenum Chambers

The air must be distributed from the circular fan to the rectangular face of the tube bundle. Air velocity through the fan will be 1,000 to 2,000 ft./min., whereas the actual face velocity is generally 300 to 700 ft./min. The plenum chamber has the function of distributing the air and changing its velocity. The plenum chamber depth, from fan to tube bundle, is usually about half the fan diameter, although fan manufacturers prefer a depth equal to the diameter.

The fan ring must be made to commercial tolerances for the relatively large-diameter fan. These tolerances are greater than those for the closely machined fan rings used for small-diameter-fan performance testing. Fan performance is directly affected by the increased clearance between the blade tip and the ring and the design must allow adequately for the consequent reduction in air flow.

Depth of the fan ring is a critical quantity. Worsham[11] reports an increase in flow of 5 to 15% with the same power consumption when the depth of the fan ring is doubled. The percentage increase was proportional to the volume of air and the static pressure against which the fan was operating.

In selecting a fan, its over-all performance curve should be considered. One factor that should be reviewed is the stall-out condition that develops when the fan can produce no more air, regardless of the power supplied.

The supporting structure for the cooler must be designed and braced to minimize vibration. Appurtenances such as fan guards, walkways and ladders are installed as needed.

Forced Vs. Induced Draft

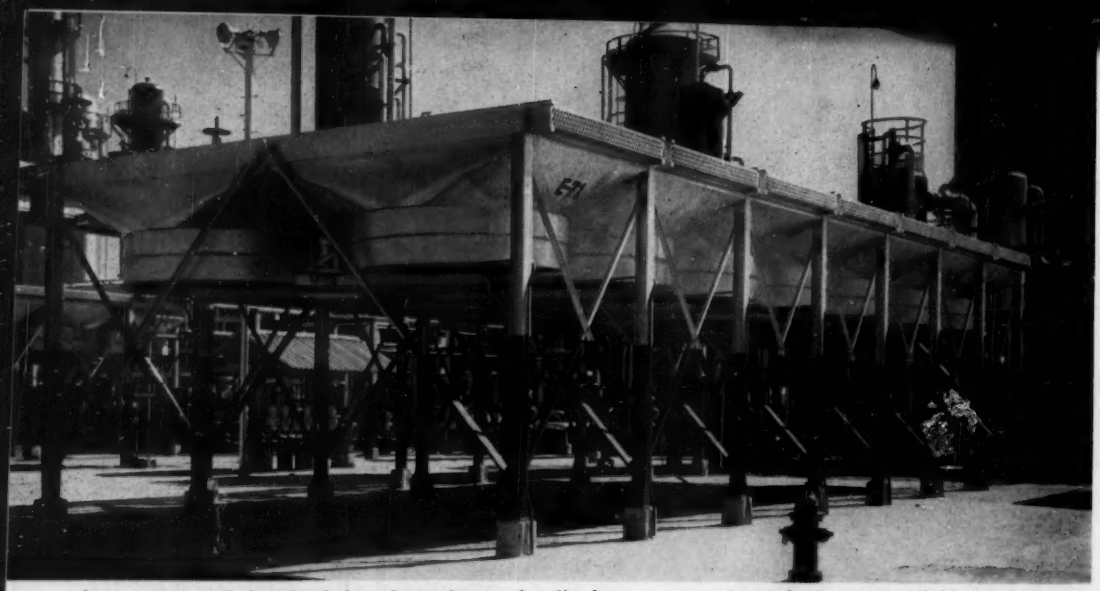
In a forced draft unit, the fan pushes the air across the finned tube surfaces, the fan being located below the tube nest. In the induced draft unit, the fan is above the bundle and pulls air through the bundle and across the finned tube surface.

In theory, a primary advantage of the forced draft unit is that less horsepower is required. Actually, however, the smaller diameter fan that is required by the mechanical design takes more power, which cancels the theoretical saving. As for the induced draft fan, it gives better air distribution and less air recirculation.

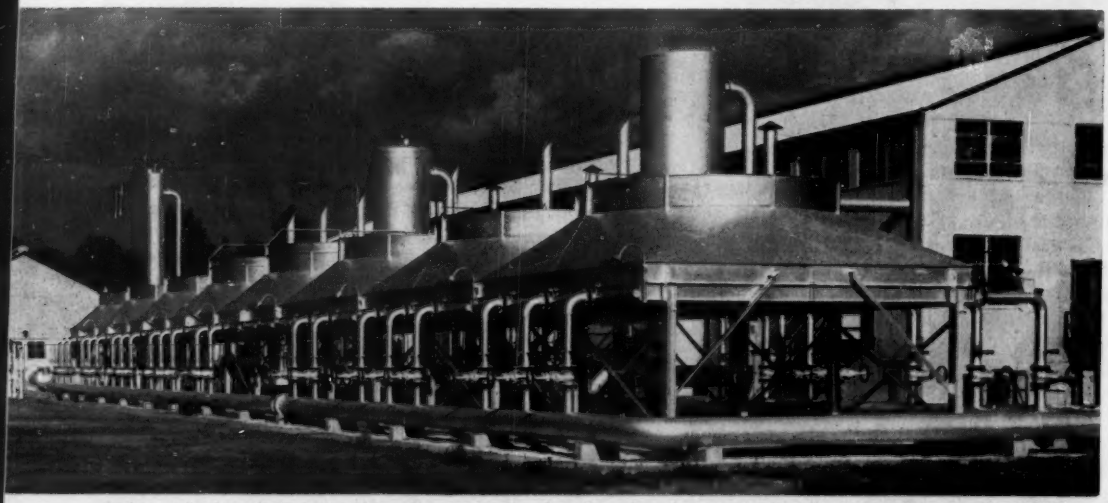
There is an actual power advantage for the forced draft unit, which comes from the fact that it moves the air before it has been heated by passage through the bundle and hence is at the highest available density. Since fans are essentially constant-volume devices, the mass of air moved by any fan is proportional to the density.

Since forced draft design locates the fan closer to ground level, structural costs will be less. The driver can, for example, be mounted at ground level.

Because the velocity of air approaching the tube



Forced draft unit has fan below the exchanger bundle, hence moves air at the lowest available temperature.



Induced draft unit has fan above the exchanger bundle, gives better air distribution and less recirculation.

bundle is relatively low in an induced draft unit, this type gives better air distribution across the bundle. Because its exit velocity is several times that of a forced draft unit, the induced draft type is less likely to recirculate the hot exhaust air. This is of particular importance where a close temperature approach is required between the fluid outlet temperature and the inlet air temperature.

Other advantages may be mentioned for the induced draft unit. This design permits the installation of air cooled equipment above other mechanical equipment such as pipe racks or shell and tube exchangers. And, in types of service where sudden temperature changes would cause upset and loss of product, the induced draft type gives more protection since only a fraction of the surface, as compared with a forced draft unit, is exposed to the rain, sleet, snow or blazing sun.

Outlet Temperature Control

There are several ways to obtain temperature control of the process fluid outlet of the exchanger:

- Manually adjusting the air-flow rate by: (1) using multiple fans; (2) using two-speed motors; (3) manually adjusting the fan blades.
- Using an automatic temperature controller to control a bypass for the process fluid.
- Using an automatic temperature controller to control air flow by operating shutters.
- Controlling air-flow rate by using a temperature controller to control a variable-speed drive motor or steam turbine.
- Controlling a variable-pitch fan from a temperature controller. This is the method with the highest initial cost, but it has the lowest operating cost for close temperature control.

The variable-pitch propeller require a controller with an adjustable throttling range. A range of about 10% of the total range of the instrument is recommended for heat exchanger work. Using a wider range would require a greater fluctuation before the fan blades would change pitch, while a narrower range

would result in a tendency to cycle. (A full discussion can be found in the previously mentioned Article V of Hartzell Propeller Fan Co.)

Power and air delivery of a fan can be controlled by adjusting either fan speed, or blade pitch, or both. Multiple-speed motors allow a limited amount of control, but control apparatus is expensive. With large banks of multispeed motors, severe surges in line current occur when the motors are switched on and off.

Manual pitch adjustment requires a shutdown period that is sometimes not permissible.

Fans with automatically adjustable pitch allow the blade angle to be altered in operation. Reduction in blade pitch not only reduces the air flow but also effects a saving in power. The range of blade angle adjustment should allow for pitch changes from full design air flow to reverse pitch at the blade tip. This should be accomplished with a minimum of hysteresis. Some control may be lost if the blade setting will not be the same for the same control signal, regardless of whether the blade angle is being increased or decreased.

To reduce the cooling capacity of an air cooler, it is necessary only to decrease the air flow. Louvers will do this but at no power saving. Power and air quantity are both adequately regulated by controlling either speed or pitch, or both.

Pointers on Design

Design Air Temperature—Maximum ambient temperatures will be 10-20 F. higher than the maximum dry-bulb design temperature selected on an economic basis. Some specifications use the average daily maximum temperature for the hottest month of the year. Others use a temperature that will not be exceeded more than 5% of the time during the three hottest months of the year.

Air Recirculation—Warm air recirculation must be taken into consideration. Segal[7] reports that "it is believed practical to add 5 F. for the possible ambient rise due to recirculation of hot effluent air." Recirculation by induced draft fans is considerably less than with forced draft installations. Note too that the spacing of adjacent air coolers and the location of other equipment may be factors in influencing the amount of hot air recirculation.

Winter Operation—Factors peculiar to winter operation include possibility of freezing of the process liquid or freezing of moisture on the fins. Use of excess air and possible difficulties from heavy rains and strong winds should be considered.

Noise—The noise level for several identical fans operating in parallel is only slightly greater than that of a single fan operating at the same tip speed.

Space Requirements—Published comparisons of the over-all space requirements for coolers using air cooling and water cooling are not consistent. This may be due to the inclusion of cooling tower area in some studies but not in others. Perkins[6] reports that less total land area is needed for air cooled exchangers. Segal[7] claims that area requirements for air fin coolers are some 15-20% greater than for shell and tube exchangers.

In some installations, air cooled units have been placed above other equipment such as pipe racks and shell and tube exchangers. Other plants avoid this practice, owing to safety considerations as discussed below.

Safety—In both shell and tube and air cooled exchangers, the weakest point is generally at the tube-to-tubesheet joint. If leakage should occur at this point in a shell and tube exchanger, no immediate danger will develop, because the fluid is not exposed to the atmosphere.

Conversely, in an air cooled unit, such a leak is directly to the atmosphere and may lead to fire or toxic fume hazards. However, the large air flow through an air cooled exchanger greatly reduces the concentration of the escaping fluid. Segal[7] reports that air fin coolers "are not located over pumps, compressors, electrical switch gear, control houses. In general, the amount of equipment such as drums and shell and tube exchangers located beneath them should be minimized."

Atmospheric Corrosion—Air coolers should not be situated where corrosive fumes and vapors from vent stacks will pass through them. The nature of chemical fumes in the general area should be given due consideration.

Air-Side Fouling—Air-side fouling is generally negligible. Sand and insects are sometimes held at the fins but the surfaces can be kept clean by steam cleaning, hot water spray or hand brushing.

Process-Side Cleaning—Either chemical or mechanical cleaning on the inside of the tubes is feasible and can readily be accomplished.

Process-Side Design Pressure—The high pressure process fluid is always in the tubes. Tube-side headers are relatively small as compared with water cooled units, and design for high pressure is relatively simple.

Bond Resistance—The bond between fin and tube has an effect upon the amount of heat transfer through the fin tube and so should be taken into consideration. Young and Katz[8] reported on the variation in bond resistance as a function of the number of thermal cycles for integral finned duplex tubes. Vibration and thermal cycling affect the bond resistance of various types of tubes in different ways.

Mean Temperature Difference—For a zero degree approach, i.e., when the outlet temperatures of both fluids are the same, the MTD correction factor for shell and tube exchangers is about 0.8 (for single-pass shell and two or more tube passes). For a single-pass air cooler, this factor becomes 0.91. For multiple "over-and-under" passes, the factor is 0.96.

Air Distribution—Air distribution across the tube bundle rarely is uniform. Thermal design should allow for a decrease in effectiveness of the unit as compared with small test bundles. Mechanical design may make provision for distribution baffles to equalize air flow.

Maintenance Cost—Maintenance cost for air cooled equipment comes to about 30 to 50% of that for water

cooled shell and tube coolers when cooling tower costs are included.

Operating Costs—Power requirements for air coolers will vary throughout the year if the amount of air moved is varied. Maximum power will be needed for only a fraction of the time, and cost studies should consider this fact.

Performance Tests—As in the case of shell and tube coolers, performance tests are made soon after the unit is installed to make certain it performs as specified. Later tests are made to determine the need for maintenance work or the need for additional units.

Heat balances and the comparison of measured tube-side duty with air-side duty are used to check the accuracy of test data. A balance within 10% should be expected. Over-all heat transfer rate is the criterion of performance. Design outside transfer rate may be corrected for measured air flow rate by the formula:

$$\left(\frac{W_{ma}}{W_{da}}\right)^{0.55}$$

where W_{ma} equals measured air flow rate and W_{da} equals design air flow rate. Where there is no phase change, the tube-side transfer rate may be corrected by:

$$\left(\frac{W_{mt}}{W_{dt}}\right)^{0.8}$$

where W_{mt} equals measured tube-side flow rate and W_{dt} equals design tube-side flow rate.

Air-side flow rate is best measured by using a revolving-vane anemometer and making 30-sec. measurements in equal areas on the face of the tube bundle. Net free face area (total face area less dead wood), times the velocity determined by the anemometer, gives the air flow rate.

Average air temperatures, both ambient and exhaust, are best determined by a grid of calibrated thermocouples spaced in equal areas of the tube bundle.

Air Plus Water Cooling

Trim Coolers—When ambient air temperatures cannot readily cool the process fluid to as low a temperature as desired, the combination of air cooler and water-cooled trim cooler is used. When approach temperatures of less than 40 F. are required, a combination of air fin coolers and conventional shell and tube water coolers should be investigated. Kern and Seaton[3] developed an equation for establishing the optimum intermediate temperature for a fluid leaving the air cooler and entering the water-cooled trim cooler.

Evaporative Cooling—When outlet process temperatures must be too low for economical use of air cooling alone, another method of applying supplementary water cooling is to make use of its evaporation into the air stream. Water sprayed into the incoming air stream of induced-draft units can effectively precool the air. A relatively small amount of untreated water is required. Proper control eliminates spray carryover. However, evaporative cooling can bring problems of fogging, freezing and vapor recirculation.

In designing an air cooled exchanger, it is necessary to consider the balance between capital cost and operating cost. Smith[8] examined three air coolers designed for the same service and found the ratios of power consumption and capital cost to be in inverse order, as shown:

	Unit 1	Unit 2	Unit 3
Fan power ratio	1.0	0.45	0.33
Capital cost ratio	1.0	1.11	1.38

It is clear that horsepower needs are reduced considerably as the initial cost increases, so the user must consider both initial and operating costs in developing the design best suited to his own needs. Power costs are clearly of prime importance and will have a definite effect on selection.

The possibility of using air coolers that operate without fans and thus need no power was discussed in Ref. 1, along with "the need for better (not less) water cooling."

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Meet the Author

FRANK L. RUBIN's *name has appeared at the top of almost a dozen articles in this magazine in recent years. A chemical engineer by training, he has just been advanced by Downingtown Iron Works, Inc., Downingtown, Pa., to the position of product engineer for heat transfer equipment, with responsibility for all engineering and estimating functions for heat transfer and other processing equipment. His broad knowledge of the heat transfer field led to his appointment as section editor for heat transfer equipment for the forthcoming 4th edition of Perry's "Chemical Engineers Handbook." In addition to his editorial function, he has authored several parts of his section, this being one.*

Statistics for the Cost Estimator

Statistical examination of your cost records may provide better estimates in future jobs.

STANLEY A. GERTZ
ROBERT F. DENNEE
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How often have you solved problems like this: "A 10-ft.-dia. tank contains water 15-ft. deep. How long does it take to empty the tank through a 1-in.-dia. hole that's 6 in. above the tank bottom?"

After solving such a problem, you might well ask "How did the water get into the tank in the first place, and who was so foolish to cut the hole and let it run out?" But the main reason for solving problems of limited engineering significance is to point out a particular application of a specific tool from the mathematical bag of tricks. Though we will not attempt to teach statistics here, we do want to demonstrate the usefulness of statistical evaluation for capital cost estimating.

What Is a Cost Estimate?

For us—with a background in chemical plant and refinery contracting—an estimate can be divided into several main classifications:

- Material cost.
- Construction labor cost.
- Engineering cost.
- Profit and overhead.

We'll consider only the first of these in detail.

Labor and engineering costs depend in some way on the material, but not necessarily on material cost. For example, neither installation nor engineering would vary significantly for an identical equipment piece whether made of carbon steel or stainless steel. But the cost of these materials might be in a ratio of 1 to 5 or 10. This points out the importance of estimating materials and establishing relationships to materials rather than to material costs.

The most accurate way to make a material estimate is to use the final design quantities and to price each piece of material. But final design is not available to the estimator, and often neither is a preliminary design—particularly for relatively low-cost items. It's just too costly to provide these designs.

Materials for process units can be divided into two main classes: equipment and bulk. The former contains relatively few, large pieces of equipment that meet specific process requirements, such as vessels, pumps, exchangers, furnaces and columns. The latter class includes thousands of equipment items—piping, wire, conduit, structural steel, etc.

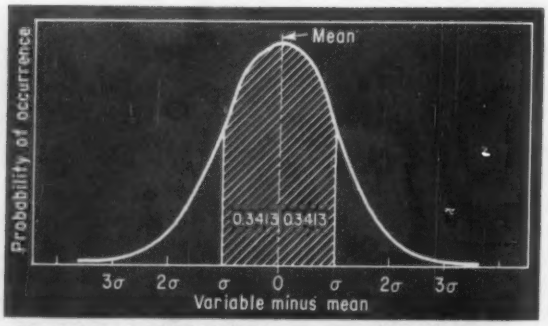
Because there are, in the equipment class, a few pieces worth a large amount of money each, a preliminary or estimated design is economically feasible, or a particular catalog item can be chosen. For example, to estimate a tower, we can start with diameter set by quantity of flow, height set by number of trays (and their spacing and holding time), thickness and material of shell set by pressure, temperature and character of flowing process material. After adding other primarily structural information, the price can be determined.

The magnitude of continuing such a procedure into the bulk class equipment would be a nightmare. Yet the bulk class can't be overlooked or diminished in importance because a large portion of the total labor to install a unit is due to these materials. Material cost of a piping system may be 15-25% of the entire material cost, but labor to install this piping may be 40% of total labor cost.

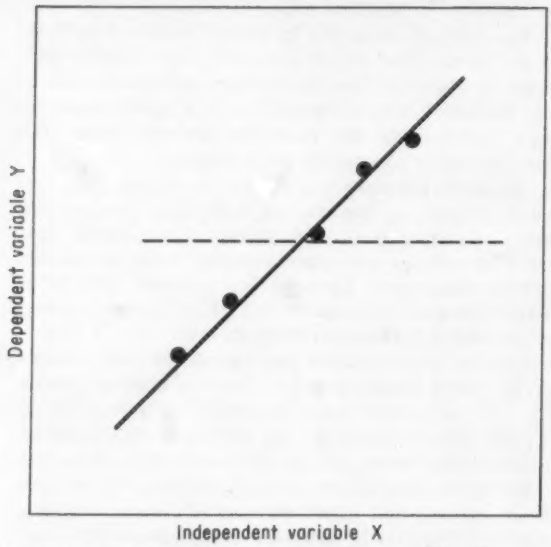
The constant conflict between need to arrive at an accurate estimate of the bulk materials and limited amount of time available to do so forces the use of any and every tool at our disposal. Statistics is one of these tools.

Applying Statistics to Your Data

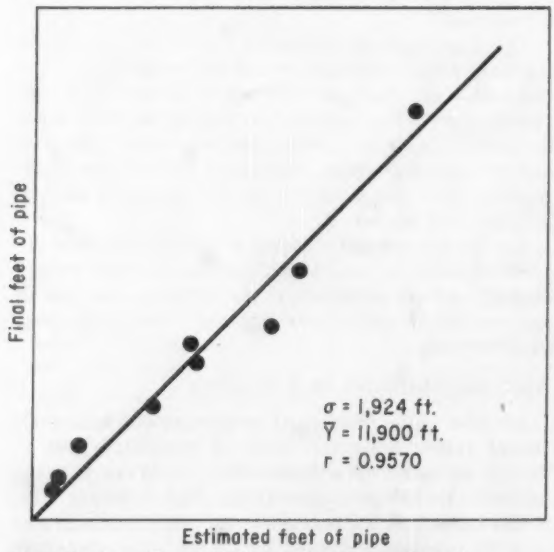
Solution to the problem of estimating bulk materials should follow a logical study of completed jobs to determine measurable independent variables and the variables that depend upon them. Such a program includes collection, arrangement and statistical analysis of final job data, followed by design of a procedure



Standard "normal" distribution curve.—(Fig. 1)



Least-squares line provides best fit of data.—(Fig. 2)



Statistics is easily applied to estimating.—(Fig. 3)

that requires measurement, counting or otherwise finding the independent variables, and calculation of the quantity of the dependent item, using the statistical result.

Time spent in the development of such an estimating system is directly related to ability of the personnel using this approach. The inexperienced may have to try every possible combination of the gathered data to arrive at the most acceptable relationships. Misleading results still can occur if experience and common sense aren't brought to bear on the problem. It may be found, for example, that cost of a crude unit is dependent upon population of the state in which the unit is to be built! Individuals completely familiar with the physical aspects of the problem can try a logical approach, however, and should obtain an acceptable answer in a much shorter time.

Having defined the area of application, let's review some of the statistical principles. The Gauss or standard normal distribution, Fig. 1, indicates that within a given "population," plotted occurrence of certain phenomena will take a characteristic shape.

The characteristic shape indicates that the value of the variable occurring at the high point of the curve is the mean value, and that there are an equal number of items occurring both larger and smaller than this value. Of the area under the curve, 68% encompasses the range of plus to minus the first standard deviation σ from the mean.

By itself, this doesn't produce much more than the probability of a desired item falling within a fixed range. But some value can be seen in the assignment of a deviation to an estimate. Without it, the question of how good an estimate is will be answered by an estimated accuracy. Using deviation, the answer may be stated as plus or minus a definite dollar value with expectation that the answer is true 68% of the time —68 out of 100 estimates.

When two or more mutually independent items are considered together, the combined deviation isn't the sum of the deviation for each; it's the square root of the sum of the squares of the deviations. The simultaneous occurrence of maximum deviation in the same direction for items that don't depend on one another is rare. Obviously, it's better to break a problem into as many pieces as practicable to take advantage of the probability that when one piece is high, another may be low to offset the over-all error.

If we must estimate a complete job to within ±20%, and if this job can be broken down into four equal cost parts, we need to estimate each piece to within ±10% to obtain the desired result. The probability that each part will vary in the same direction is such that 68% of the time, total variance will remain within 20%.

Least Squares and Correlation

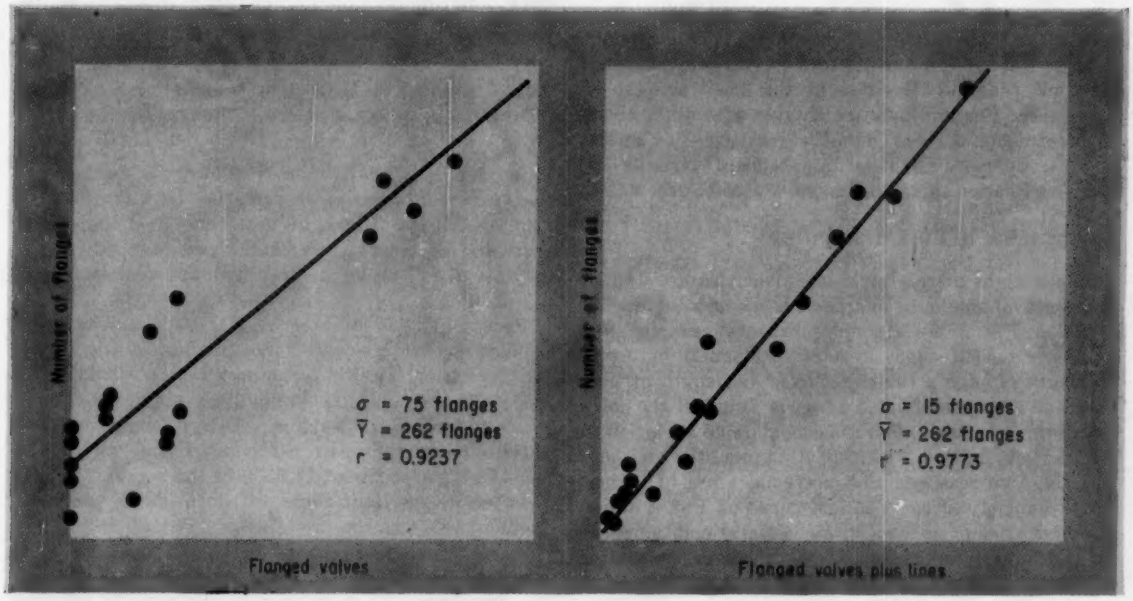
Determination of relationships between those material items that are counted and those that are not is aided by drawing graphs that show actual value of a proposed dependent variable as Y and actual value of the proposed independent variable as X. The line

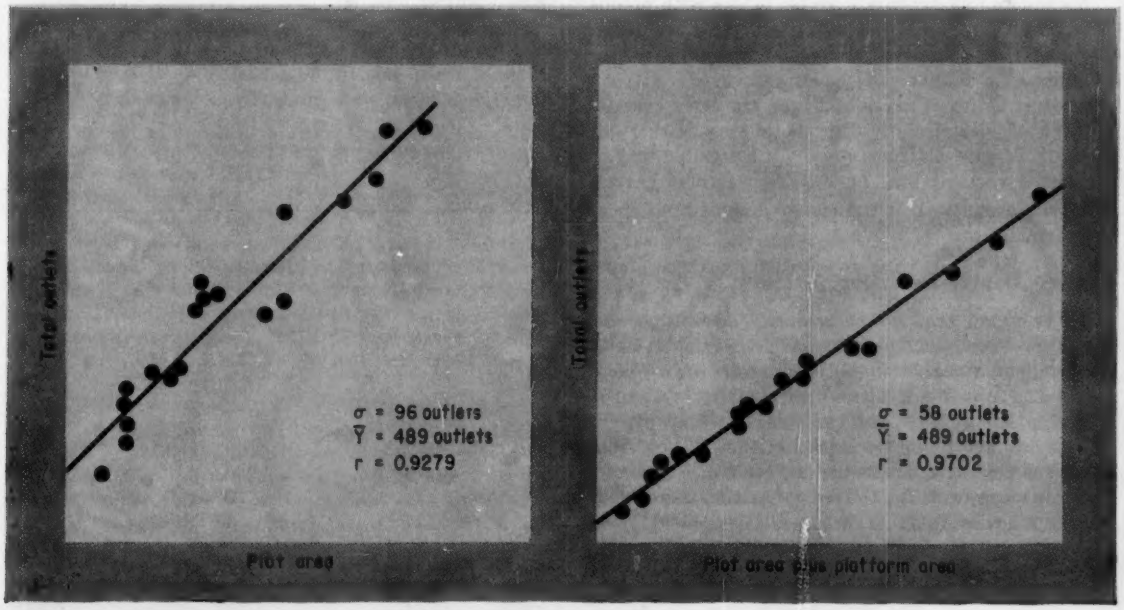
that best fits the data points is found by the method of least squares.

This method provides the line that fits the points such that the arithmetic total of all the numerical difference between the points and the line is zero, and the total of the squares of the differences is a minimum. Fig. 2 is a sample. By employing the actual values plotted (and the best-fit line) it's possible to calculate the first standard deviation and to use it as a measure of the accuracy of prediction of the dependent variable.

Perhaps most important is to determine exactly which variables are dependent and which are independent. It is best to direct your efforts to determining a small deviation for relatively high-cost items and accepting a larger deviation in other items. A 40%

Two cases here show that careful variable selection improves correlations—(Figs. 4, 5)





deviation in an item whose cost is 40% of the total will yield a relative effect of about 16%; a 40% deviation in an item whose cost is 10% of the total will yield a relative effect of approximately 4%.

Correlation shows whether we have chosen a good relationship. The coefficient of correlation r represents the relative control exerted by the independent variable on the dependent variable. For perfect correlation, $r = 1.00$. It's seldom that we obtain this value because it means that there are no conditions, aside from the independent variable, that affect the dependent variable.

The measure of reliability or confidence in a statistical solution depends on the deviation, correlation and number of observations. Two observations or points yield zero deviation and perfect correlation, but they have low reliability because of the small amount of experience. For minimum acceptable reliability, about 10 points should be examined. Sometimes it's necessary to use more than one independent variable because correlation to any one is too low to be acceptable.

Applications to Cost Estimating

Applications of the foregoing principles are limited only by available data and the imagination of the individual. Fig. 3, for example, measures completeness of piping takeoff (done by same personnel) by a plot of length of pipe actually required vs. length of pipe taken off or approximated at early stage in the job.

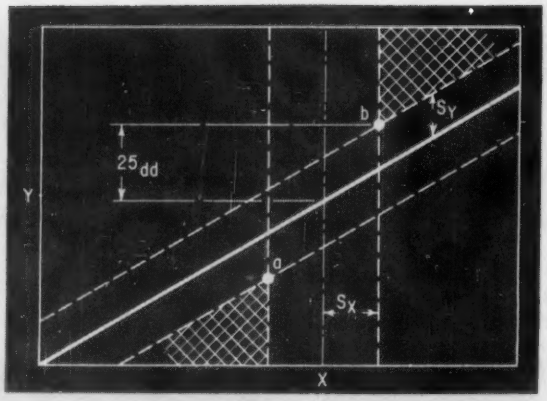
In piping systems, there is considerable variation in number of flanges. To find this quantity without counting, we reasoned that a frequent use of flanges is for flanged valves. The left curve of Fig. 4 shows our first attempt at correlation. Several points appear on the Y axis, indicating a use of flanges where no valves were used. No prediction is possible for these cases, and the line is offset for all other cases.

We had to find another variable to use with number of valves to correct this situation. The right-hand curve of Fig. 4 shows the effect of including number of lines with number of valves. Obviously, the correlation is better. Curves of Fig. 5 similarly correlate number of electrical lighting outlets vs. either plot area or plot-plus-platform area. (It's possible that the additional variable may have to be weighted.) In all these correlations, $\overline{Y}$ is the mean value of the dependent variable.

Putting Double Deviation to Use

We've found that it's occasionally advantageous to use a previously defined dependent variable as the independent variable in determination of a specific item. The amount of fittings in a piping system depends on use of pipe, for example, but final pipe requirements are found by a prediction. It's necessary to have a method to determine deviation of a dependent variable when basis for the determination is a variable having a deviation of its own.

Assuming that the X value is the "definite" quantity in Fig. 6, a line and first standard deviation can be found for Y. This isn't a true first standard deviation, however, because of variation that may be encountered in X. But since variations in X and Y are mutually independent, we can assume that X (as well as Y) will fall above its first standard deviation 16% of the time.



"Double deviation" results when previously defined dependent variable becomes the "independent" variable.—(Fig. 6)

Probability of occurrence of these mutually independent events is equal to the product of the probability of each, i.e., the combined events would occur 2.56% of the time. The same logic applies to events below the two variables' first standard deviations. The probability of falling within points a and b of Fig. 6 is 94.88%; approximately 95% of the population falls between these limitations—a variation of approximately two times the first standard deviation.

In solutions to problems of this nature, the first standard deviation is equal to the deviation in Y plus the deviation in X multiplied by the slope of the line, all divided by two.

$$S_{dd} = (S_Y + mS_X)/2$$

It's important to remember that although the actual value of Y depends on the actual value of X, the deviations in each must be mutually independent.

This article is based on a paper presented at the 4th annual meeting of the American Assn. of Cost Engineers, June 13-15, 1960.

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New Data on Entrainment From Perforated Trays At Close Spacings

This article describes a comprehensive study of entrainment with a dynamic system in equipment that is large enough to permit use of the results for commercial designs.

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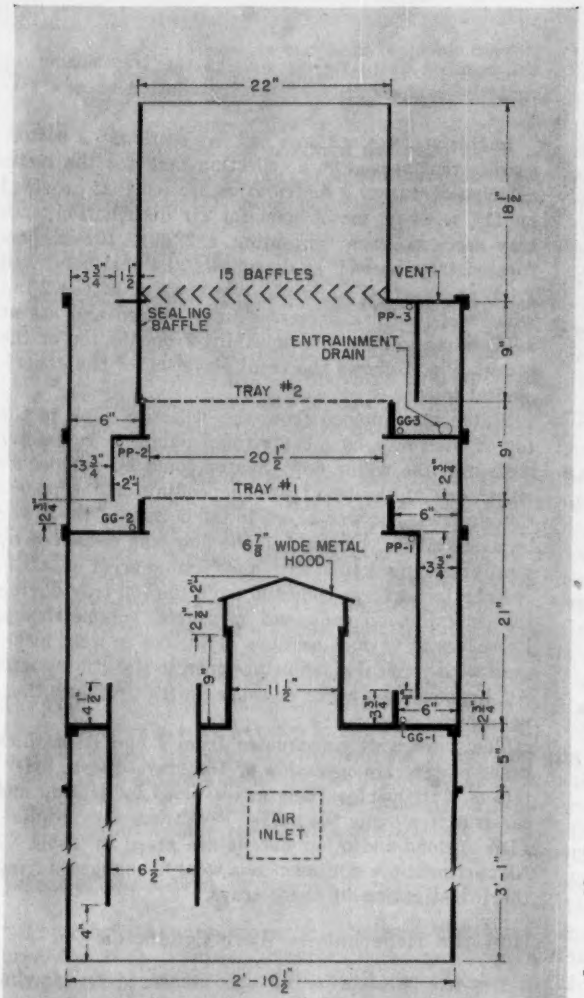


Tray and tower details—Table I

	Type Tray				
	1	2	3	4	5
Top downflow area, sq. ft.	←		0.432		→
Bottom downflow area, sq. ft.	←		0.27		→
Underdownflow area, sq. ft.	←		0.198		→
Between downflow and seal pot, sq. ft.	←		0.144		→
Tray plate area, sq. ft.	←		1.475		→
Tower superficial area, sq. ft.	←		2.48		→
Height of seal pot dam above tray, in.	←		1		→
Weir length, in.	←		10-3/8		→
Length of liquid path, in.	←		22-1/2		→
Tray thickness, in.	1/8	3/16	3/16	3/16	1/8
Hole diameter, in.	3/16	1/2	3/16	3/8	3/16
Triangular hole spacing, in.	9/16	1-11/16	9/16	1-1/8	1/2
Number of holes	735	84	735	189	936
Hole area per tray, sq. ft.	0.141	0.1145	0.141	0.245	0.179
Hole area, % plate area	9.6	7.8	9.6	9.8	12.2

This article reports data on liquid entrainment for perforated bubble trays with 6-in., 9-in. and 12-in. tray spacings for an air-water system. Five different trays were studied with hole diameters of $\frac{3}{16}$ in., $\frac{3}{8}$ in. and $\frac{1}{2}$ in., and tray thicknesses of $\frac{1}{8}$ in. and $\frac{3}{16}$ in. Hole areas varied from 7.8% to 12.2% of the plate area.

We found that entrainment increases with weir height, vapor velocity and hole size. But entrainment decreases with increased tray spacing.

Depending on the vapor velocity, entrainment increases or decreases with liquid rate. Some hydraulic characteristics (pressure drop and froth height on the trays) are also included with the results presented in this article.

The work described here is a comprehensive study of entrainment with a dynamic system in equipment that is of sufficient size to permit use of the results for commercial designs.

As tower designs become more and more competitive and the trend toward smaller tray spacings becomes more pronounced, a better understanding of entrainment and the factors that affect it becomes more important to the design engineer.

A tower can be designed to operate at conditions of high entrainment if sufficient trays are added to

Nomenclature

e'	Entrainment, lb./lb. of air.
E	Efficiency without entrainment.
E_e	Efficiency with entrainment.
L/V	Reflux ratio, lb. liquid/lb. vapor.
R_h	$\frac{\text{True vapor velocity in hole area, ft./sec.}}{0.227[(\rho_L-\rho_V)/\rho_V]^{0.5}, \text{ ft./sec.}}$
R_p	$\frac{\text{True vapor velocity in plate area, ft. sec.}}{0.227[(\rho_L-\rho_V)/\rho_V]^{0.5}, \text{ ft./sec.}}$
u_p	Air rate in plate area, ft./sec.
Z_f	Tray froth height, in.
Z_t	Tray spacing, in.
Δp_t	Total pressure drop, in. of water.
ρ_L	Liquid density, lb./cu. ft.
ρ_V	True vapor density, lb./cu. ft.

compensate for the adverse effects of entrainment on efficiency, and if the trays have sufficient capacity to handle the liquid and vapor loads.

A simple relationship between apparent efficiency and entrainment was derived by Colburn[6] and has been recommended for use in design by the Research Committee of the American Institute of Chemical Engineers.[7]

$$E_e = \frac{E}{1 + [(e'E)/(L/V)]}$$

Towers with low apparent efficiencies operating at high reflux ratios can handle considerable entrainment without any appreciable effects on the efficiency of fractionation. Towers with high apparent efficiencies operating at low reflux ratios can sustain only a small amount of entrainment without a considerable lowering of efficiency.

The present investigations on low tray spacings were initiated during the development of an air fractionating process. The use of low tray spacings is particularly advantageous in low-temperature processes, in distillations requiring a large number of trays and in towers being installed in buildings, trailers and ships, where headroom is limited.

Designs that use low tray spacings have become increasingly important as the technology of superfractionation has proceeded from the laboratory to the commercial plant.

This article examines the effects of tray spacing, weir height, hole size, hole area, plate thickness and vapor and liquid rates on entrainment. Pressure drop and tray froth level are also reported for the $\frac{3}{16}$-in.-dia. tray on a 9-in. tray spacing.

Description of Experimental Column

Our experimental column consisted of a 2-ft., $10\frac{1}{2} \times 10\frac{3}{8}$-in. rectangular shell made of $\frac{1}{2}$-in. plywood. The internal members, downflow plates, seal pots and tray supports, were constructed of $\frac{1}{4}$-in. plywood. Tray and downflow action was observed through $20\frac{1}{2} \times 5$-in. windows on either side of the tower between each tray and $5\frac{3}{4} \times 6$-in. windows on each end of the shell.

The tower shell consisted of flanged sections so that the number of trays—as well as the tray spacing—could be varied easily by the installation of new sections.

In this study, the tower had five sections: a bottom section that served as a collection tank for the recirculation of water; a distribution section that provided an $11\frac{1}{2} \times 6\frac{3}{8}$-in. metal hood for air distribution; two tray sections, each containing a $22\frac{1}{2} \times 10\frac{3}{8}$-in. perforated tray, as well as downflows and seal pots; and a top section that contained two rows of fifteen 2-in.-wide $\times$ $\frac{1}{4}$-in.-thick louvers equally spaced and set at a 45° angle to minimize splashing from the top of the tower. Fig. 1 shows the front elevation of the experimental tower.

Water was pumped from the collection tank to the top of the tower by a centrifugal pump. A rotameter measured the water flow. Water could be pumped to either one of the two trays, depending on the operation desired. Air was blown to the bottom of the tower by a centrifugal blower and the flow was measured by a calibrated pitot tube with a maximum error of ±5%.

Entrainment was collected from the top tray during the entrainment runs and measured volumetrically. Pressures at various sections of the tower were measured with vertical manometers open to the atmosphere. All temperatures were measured with ordinary thermometers.

The trays were constructed from $\frac{1}{8}$ and $\frac{1}{16}$-in.-thick brass plates. Maloperation of the trays due to orientation of the perforations was avoided by drilling and carefully removing the burrs. Five trays were studied. (Dimensions and other details are given in Table I.) All pertinent tower dimensions were unchanged during the investigation of these trays.

How the Experiments Were Conducted

Dry-tray pressure drop was measured by blowing air to the bottom of the tower and measuring the pressure at each tray section. During these measurements, there was no water on any of the trays. Downflows were sealed by filling the seal pots with water. Total pressure drop across the operating tray was obtained during the entrainment runs by the difference in manometer readings.

Generally, liquid rates were set as follows: 500, 1,000, 2,000, and 3,000 gal./hr. Unless otherwise stated, the liquid rates in this article are expressed as gal./hr. at flowing conditions per inch of exit weir.

Air flow was set at the lowest value of interest and increased by increments until the tower became inoperable due to excessive entrainment or to downflow flooding. Vapor velocities are generally expressed as R_p or R_h—that is, as the ratio of the vapor velocity in the plate area or hole area to allowable (or base) velocity—and are dimensionless. The allowable (or base) velocity, $0.227\ [(\rho_L - \rho_V)/\rho_V]^{0.5}$, was derived from Souders and Brown.[8]

Entrainment data were obtained by measuring the water that was collected in the seal pot of the top tray. For this operation, water was pumped to the bottom tray. The top tray acted as the collector.

Air and water rates were varied in the same manner as for the pressure drop operations. The reproducibility of the entrainment results was very good. An analysis of entrainment data obtained in a similar manner showed that the observed standard error of measurement was 3.6%.[9] An abridged tabulation of the data taken during this study is given in Table II.

Effect of Weir Height

The effect of weir height on entrainment was measured with a ⅛-in.-dia.-hole perforated tray at a tray spacing of 9 in., at weir heights of 0, 1 and 2 in.

Fig. 2 on the next page gives these data at liquid weir rates of 48.2, 96.5 and 193 gal./(hr.) (in.). As this graphical presentation shows, entrainment generally increases with increasing weir height.

However, the rate of increase in entrainment is much higher going from a 1-in. to a 2-in. weir than it is from a 0-in. to a 1-in. weir. At 193 gal./(hr.) (in.) and an R_p of 0.9, entrainment at a weir height of 2 in. is 1,070% greater than at a weir height of 0 in., while it's only 67% greater at a weir height of 1 in.

As liquid rate decreases to 96.5 gal./(hr.) (in.), the entrainment at a 2-in. weir is 165% greater and at a 1-in. weir, 24% greater. At a liquid rate of 48.2 gal./(hr.) (in.), the entrainment at 0-in. weir height is lower than for a 1-in. weir up to an R_p of about 1.0.

Above this air rate, the entrainment increases rapidly and becomes equal to the entrainment at a weir height of 2 in. This rapid increase of entrainment is probably due to "blowing" of the tray.

Effect of Hole Area

The effect of hole area on entrainment was measured for ⅛-in.-diameter-hole perforated trays on a 9-in. tray spacing with holes on a ⅛-in. and a ½-in. spacing. The first tray had 735 holes and the second, 936. Plate area was constant for both trays. The difference in hole area based on the ⅛-in.-hole-spacing tray was 27%. Fig. 3 shows that up to an R_p of 1.1, increasing hole area with the same hole size has no effect on entrainment.

At higher R_p's entrainment is greater for the smaller hole area. At an R_p of 1.3, the difference is 23%.

Effect of Plate Thickness

The effect of plate thickness on entrainment was measured with a ⅛-in.-diameter-hole perforated tray at 9-in. tray spacing with a 1-in. weir with plate thicknesses of ½ and ⅛ in.

Fig. 4 shows that at all vapor rates there are no effects of plate thickness on entrainment. The thickness-to-diameter ratio for the plates tested is from 0.665 for the ½-in.-thick plate to 1.0 for the ⅛-in. There are some indications that as the thickness-to-diameter ratio increases, dry-tray pressure drop decreases.

If pressure drop were the sole factor affecting entrainment, there would be greater entrainment for the ⅛-in.-diameter-hole tray with ½-in. thickness. Fig. 4 shows that this is not the case.

Normally, in commercial applications, the minimum perforated plate thickness for carbon steel plate is No. 10 USS gage, and for alloy plate, No. 14 USS gage at any hole size. The thickness-to-diameter ratio for carbon steel plate varies from 0.282 for a ½-in.-dia. hole to 1.5 for a ⅛-in.-dia. hole, and for alloy plate, from 0.156 to 0.835.

As the effect of plate thickness has not been investigated at thickness-to-diameter ratios less than 0.665 or more than 1.5, some caution must be exercised in generalizing on the effect of plate thickness.

Fig. 5 shows the effect of hole size on entrainment. Three perforated trays were used for this study, Types 1, 2, and 4 (see Table I). All trays were studied with a 12-in. tray spacing and 0-in. weir. Fig. 5 shows that entrainment increases as hole size is increased. At an R_p of 1.0, entrainment for the ⅜-in.-dia.-hole perforated tray is 127% greater than that for the ⅛-in.-hole tray; and for the ½-in.-dia.-hole perforated tray, it is 657% greater.

Differences in plate thickness and hole area between the three trays could possibly account for small variances but not for such great ones. The difference in hole area between the ⅛-in. and ⅜-in.-dia. perforated trays is less than 3% and between the ⅜-in. and ½-in.-dia. perforated trays, about 22%.

This is about the same difference that exists between the trays on Fig. 3, which indicates that below an R_p of 1.1, hole area has no effect on entrainment. The difference in the plate thickness-to-diameter ratio between the ⅛-in. and ⅜-in.-dia.-hole perforated trays is 33%, which is less than the difference between the trays in Fig. 4.

Admitting that there could be some slight difference due to hole area and plate thickness, the great difference shown on Fig. 5 can be due only to the effect of hole size.

Effect of Sloping Trays

The effect of sloping trays on entrainment was measured with a tray sloped 1 in./ft. of tray length. This tray was higher at the inlet than at the outlet end.

Fig. 6 shows entrainment with a level and a sloped tray for a ½-in.-dia.-hole perforated tray, 0-in. weir, and a tray spacing of 12 in. at liquid rates of 48.2 and 96.5 gal./(hr.) (in.).

For a liquid rate of 48.2 gal./(hr.) (in.), sloping the tray has no effect on entrainment up to an R_p of 0.6; at higher vapor rates entrainment for the sloped tray is greater. At a liquid rate of 96.5 gal./(hr.) (in.), entrainment is about the same for the sloped tray at low R_p's but higher at higher vapor rates.

Effect of Tray Spacing

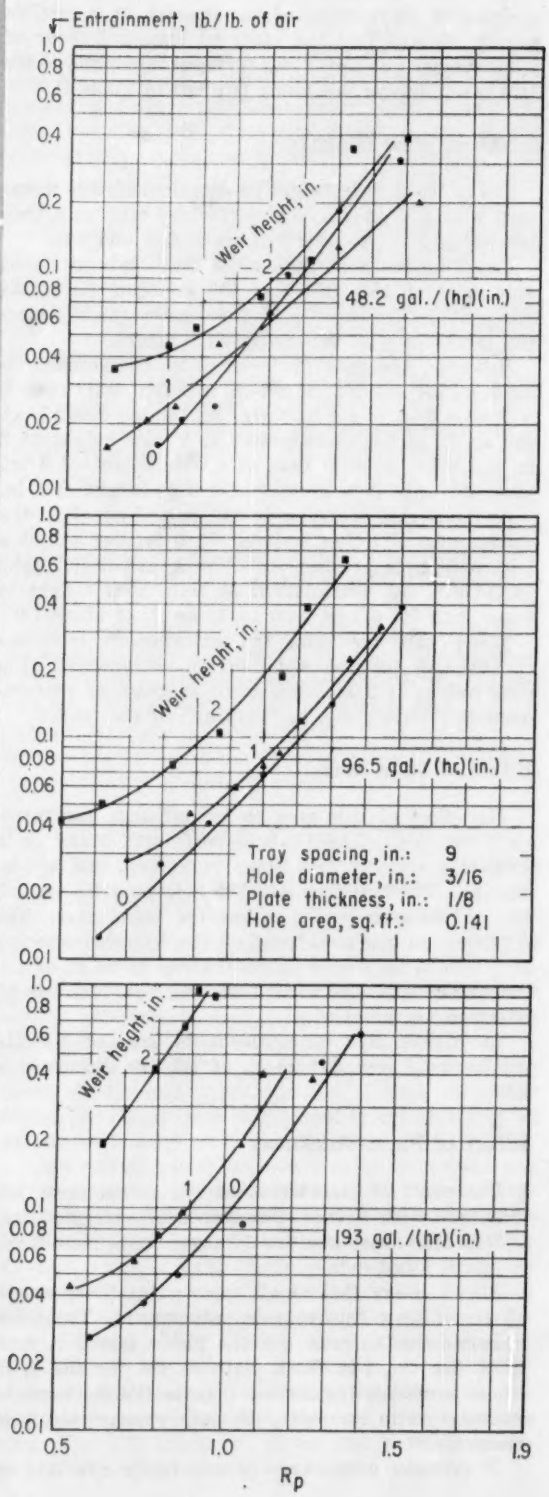
Entrainment was measured for a ⅛-in.-dia.-hole perforated tray with 1-in. weir at tray spacings of 6,

Selected experimental results—Table II

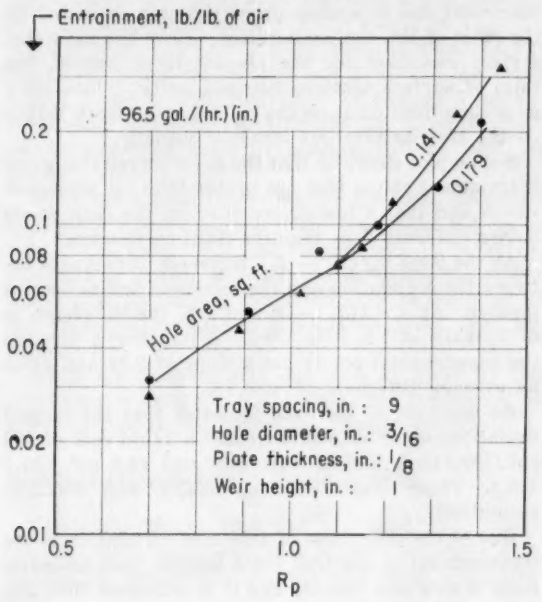
Tray Spacing, In.	Tray Type	Weir Height, In.	Gal./(Hr.)(In.)	R_p	Δp_t, In. Water	e°	Froth Height, In.
6	1	1	48.2	0.495	1.45	0.135	
				0.75	1.60	0.291	
				0.97	2.15	0.765	
			96.5	0.228	1.45	0.125	
				0.374	1.50	0.418	
				0.443	1.60	0.90	
9	1	0	48.2	0.742	1.50	0.0158	2.0-1.5
				1.15	2.85	0.0943	3.5-2.75
				1.48	4.35	0.316	6.0
			96.5	0.625	1.2	0.0125	3.0-2.5
				0.8	1.85	0.0267	3.0-2.5
				1.3	3.85	0.145	5 -3.5
			193	0.61	1.85	0.0259	3.5-3.25
				0.877	2.4	0.05	4.0-3.5
				1.4	4.2	0.607	6+
		1	48.2	0.621	1.5	0.0158	3.25
				1.1	2.8	0.0652	3.5
				1.3	3.75	0.128	3.75
			96.5	0.704	1.8	0.0278	4
				1.02	2.6	0.0597	4
				1.35	3.8	0.229	4.25+
			193	0.745	2.4	0.0579	4
				0.885	2.7	0.0947	4+
				1.06	3.2	0.191	4+
	3		96.5	0.69	1.8	0.0257	
				1.015	2.7	0.0607	
				1.29	3.95	0.2	
	5			0.7	1.4	0.0318	
				1.18	2.25	0.1001	
				1.4	2.8	0.214	
	1	2	48.2	0.645	1.85	0.035	4.5
				1.07	2.8	0.075	5.0
				1.34	4.05	0.344	7.0
			96.5	0.625	2.05	0.05	4.5
				0.97	2.65	0.107	5.5
				1.23	3.8	0.382	~8
			193	0.65	2.75	0.193	~6
				0.877	3.1	0.667	Up to T-2
12	4	0	96.5	0.665	1.35	0.01825	
				0.995	2.35	0.0735	
				1.26	3.7	0.192	
	2		48.2	0.474	1.3	0.0406	
				0.835	2.55	0.158	
				1.13	4.05	0.705	
			96.5	0.724	1.3	0.0234	
				0.781	2.45	0.1185	
				1.29	5.55	0.586	
		†	48.2	0.35	0.75	0.0185	
		†		0.665	1.3	0.118	
		†		0.736	1.65	0.226	
		†	96.5	0.383	1.15	0.0193	
		†		0.715	1.65	0.0942	
		†		0.93	2.65	0.379	
	1	1	48.2	0.545	1.2	0.0048	
				0.965	2.2	0.0229	
				1.31	3.25	0.1	
			96.5	0.607	1.45	0.00777	
				1.03	2.35	0.0254	
				1.48	4.15	0.111	
			145	0.555	1.6	0.00952	
				1.09	2.8	0.0309	
				1.41	4.1	0.0877	
			193	0.62	1.9	0.0157	
				1.17	3.2	0.0419	
				1.44	4.25	0.0974	
			290	0.735	2.25	0.0227	
				1.14	3.25	0.0497	
				1.5	4.75	0.1425	

Notes: Tray Types 1 through 5 are dimensioned in Table 1. In entries marked with a dagger, the tray sloped from seal pot to downflow 1 in./ft.

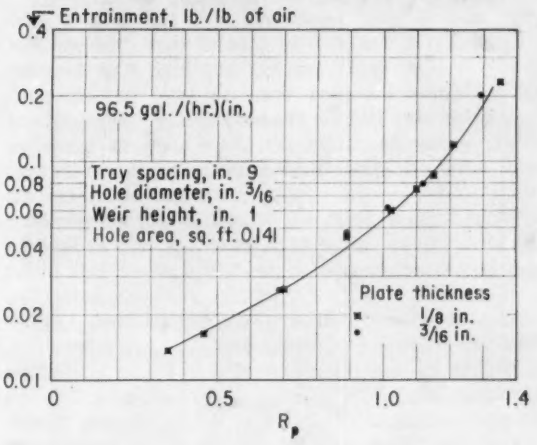
Weir height vs. entrainment—Fig. 2



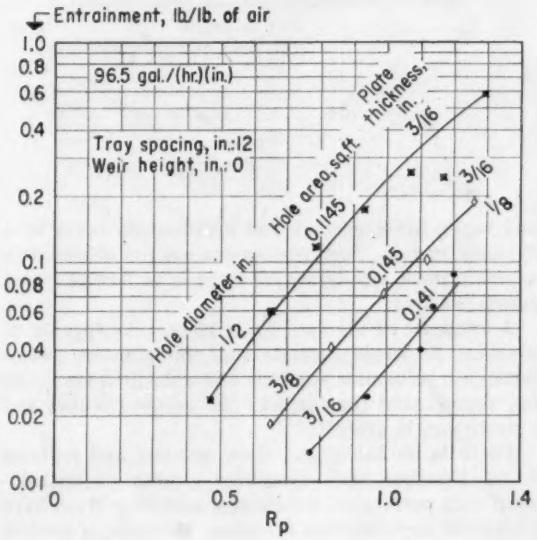
Effect of hole spacing—Fig. 3



Effect of plate thickness—Fig. 4



Effect of hole diameter—Fig. 5



9, and 12 in. Fig. 7 shows the effect of tray spacing on entrainment at a liquid rate of 48.2 gal./(hr.)(in.). It can be seen that entrainment increases as tray spacing is decreased. Based on the entrainment for the 9-in. tray spacing at an R_p of 0.9, the entrainment at a 12-in. tray spacing is 53% lower, while it is 1,400% higher for a 6-in. tray spacing.

For a liquid rate of 96.5 gal./(hr.)(in.), shown on Fig. 8, the entrainment at an R_p of 0.9 for the 12-in. tray spacing is 65% lower than for the 9-in. tray spacing. At an R_p of 0.9, the tray on a 6-in. tray spacing was inoperable at a rate of 96.5 gal./(hr.)(in.).

Notice that entrainment for a 6-in. tray spacing increases very rapidly and the slope of the entrainment curve has changed markedly. At an R_p of 0.4, the entrainment at a 6-in. tray spacing is 3,900% higher than for a 9-in. tray spacing. A plot of log entrainment versus the reciprocal of tray spacing would not give a straight line, due to the rapid increase in entrainment at the 6-in. tray spacing.

Effect of Process Variables

Fig. 9 shows the effect of liquid rate on entrainment for a tray with ⅛-in.-dia. holes with a 1-in. weir height at a tray spacing of 9 in. at liquid rates of 48.2, 96.5 and 193 gal./(hr.)(in.), and for a tray spacing of 12 in. at liquid rates of 48.2, 96.5, 145, 193 and 290 gal./(hr.)(in.).

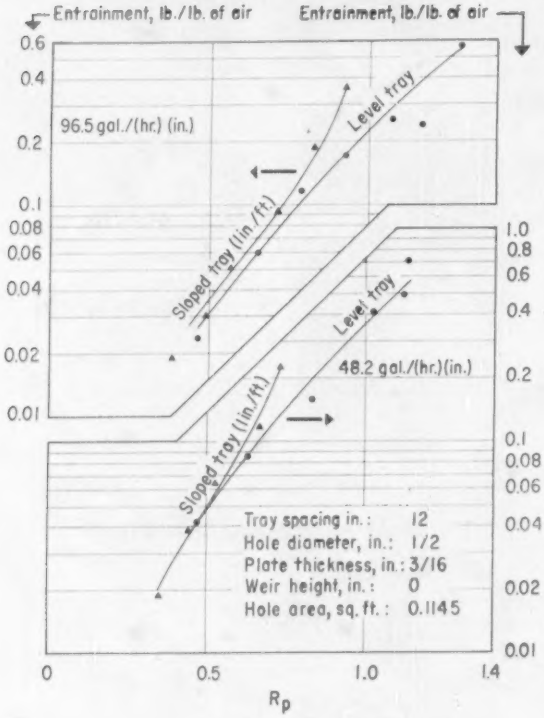
At a tray spacing of 12 in., the tower has greater liquid capacity than at a 9-in. tray spacing. At a 9-in. tray spacing, at all air rates, entrainment increases with increasing liquid rates. At an R_p of 1.0, entrainment at 96.5 gal./(hr.)(in.) is 40% greater than at 48.2 gal./(hr.)(in.), while at 193 gal./(hr.)(in.) it is 274% greater.

At a 12-in. tray spacing below an R_p of 0.9, entrainment increases with increasing liquid rates. However, at vapor rates above an R_p of 0.9, entrainment at a liquid rate of 48.2 gal./(hr.)(in.) increases very rapidly and intersects all others.

In a less spectacular fashion, entrainment at a liquid rate of 96.5 behaves in a like manner. At liquid rates of 145, 193, and 290 gal./(hr.)(in.), entrainment increases normally with increasing liquid rates.

Previous research[9] has shown that entrainment is a complicated function of liquid rate. At certain liquid

Effect of sloping trays—Fig. 6



and vapor rates, minima and maxima can occur in a dynamic system. Such phenomena are not observed in a purely static system where there is no flow of liquid across the tray.

A crossplot of the data for a 12-in. tray spacing at constant R_p would indicate that entrainment passes through a minimum at about 150 gal./(hr.)(in.). At low vapor rates, the shape of the curves changes and a maximum is present.

There is no doubt that these minima and maxima exist. Previous and subsequent studies on entrainment with perforated, bubble-cap, and other trays have furnished corroborative evidence. However, a method of predicting where they would occur has not been found. High entrainment occurs at low liquid rates and high vapor rates because of blowing of the tray.

Increasing the liquid rate has a stabilizing effect on the tray, froth height becomes more uniform and entrainment is lowered. As liquid rate is further increased, the froth height increases, gradually filling the space between trays with a corresponding increase in entrainment.

Effect of vapor rate on entrainment is given in Figs. 2 through 9. Under fixed conditions of liquid rate and tray design, entrainment increases with increasing vapor rate, as would be expected.

Comparison With Published Correlations

Hunt[4] correlated entrainment from perforated trays using the effective tray spacing (distance between the top of the foam on the tray and the tray above) and the velocity in the plate area. The difference in entrainment due to system properties was corrected by the ratio of the surface tensions. Since the air-water system was used for the present investigation, the ratio of surface tensions becomes unity. There were no assumptions made on the value for the froth height on the tray as this was obtained visually.

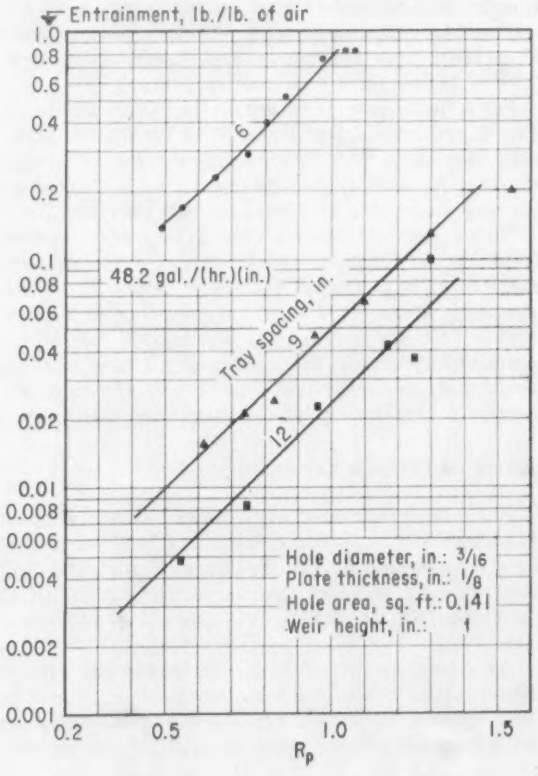
Such a plot shows us that the Hunt correlation gives entrainment values that are higher than the measured values and that a line drawn through the data would have a different slope than the Hunt correlation.

As the term $u_p/(Z_t - Z_f)$ increases, differences between the correlation and the measured values become greater. At a $u_p/(Z_t - Z_f)$ of 0.5, the difference is 67%, while at 1.5, it is 370%. A line drawn through the experimental points has a slope of 2.32 and gives an average difference of ±35.6%.

An analysis of the data indicates that the largest deviations occur at 1-in. weir and a liquid rate of 193 gal./(hr.)(in.) and at 2-in. weir and 48.2 gal./(hr.)(in.). These deviations are ±63.5% and ±87.5%, respectively.

One of the difficulties of this type correlation is the measurement of the tray froth height. This measurement is obtained visually and it is estimated that this value can be obtained with an error of ±1 in. Assum-

Effect of varying tray spacing—Fig. 7



ing a vapor velocity of 5 ft./sec. with a tray spacing of 9 in., an average value of froth height of 5 in. ±1 in., and using the best line through the data, the entrainment using values of 4 and 6 in. for the froth height would be 60% and 190% of that at 5 in., respectively. Value of froth height has a large effect on the predicted value of entrainment—at least, at low tray spacings.

When the data are correlated in the form suggested by Simkin[10] for bubble-cap trays (assuming the elevation of the top of slot and slot opening to be zero), then a line drawn through the experimental points would give an average deviation of ±35.8%, and all the predicted entrainments would be below that for bubble caps.

While the derivation is the same as given by the Hunt-type correlation, the Simkin-type correlation is better in that all the factors are readily available.

Pressure Drop and Tray Froth Height

Dry-tray pressure drop was measured for a $\frac{3}{16}$-in.-dia.-hole perforated tray with a plate thickness of $\frac{1}{8}$ in. Fig. 10 gives dry-tray pressure drop as a function of R_h.

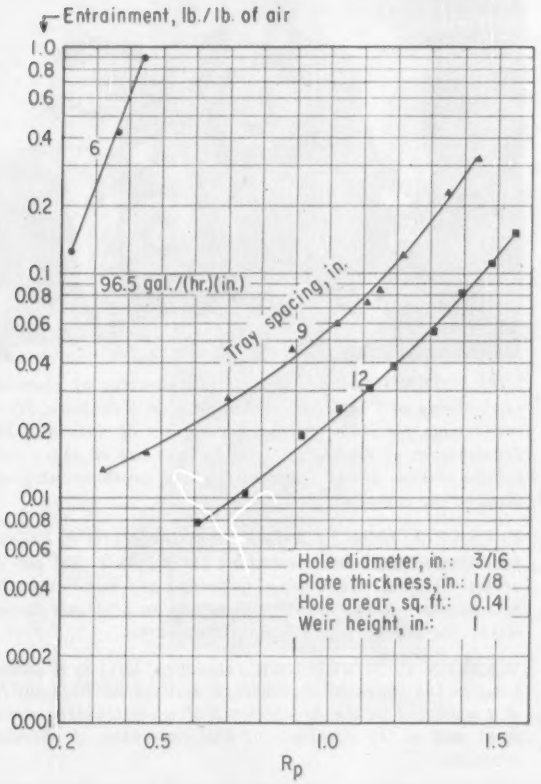
Total pressure drop across the tray was measured with a $\frac{3}{16}$-in.-dia.-hole perforated tray at 9-in. tray spacing with weir heights of 0, 1, and 2 in. at liquid rates of 48.2, 96.5 and 193 gal./(hr.) (in.).

Comparing total pressure drop calculated by the the Hughmark and O'Connell[11] method (assuming zero hydraulic gradient) and the measured values shows that all measured pressure drop points are lower than the calculated values.

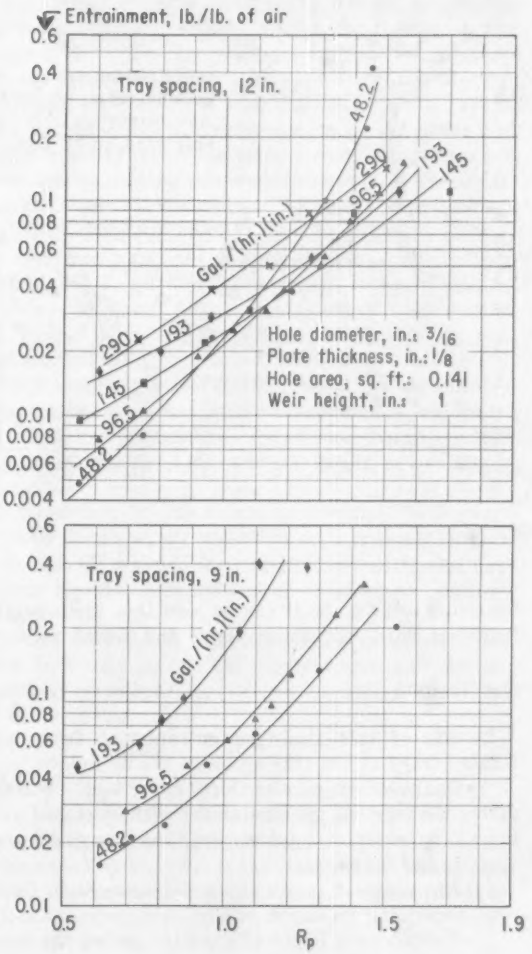
However, the hydraulic gradient term has been omitted in the calculation of the head of liquid on the tray. The average difference between measured and calculated points is 17.2%.

Tray froth height was obtained for the $\frac{3}{16}$-in.-dia.-hole perforated tray with a 9-in. tray spacing and weir heights of 0, 1 and 2 in. at liquid rates of 48.2, 96.5 and 193 gal./(hr.) (in.). Tray froth heights were obtained visually and it is estimated that the error of observation is ±1 in. Fig. 10 shows the froth height

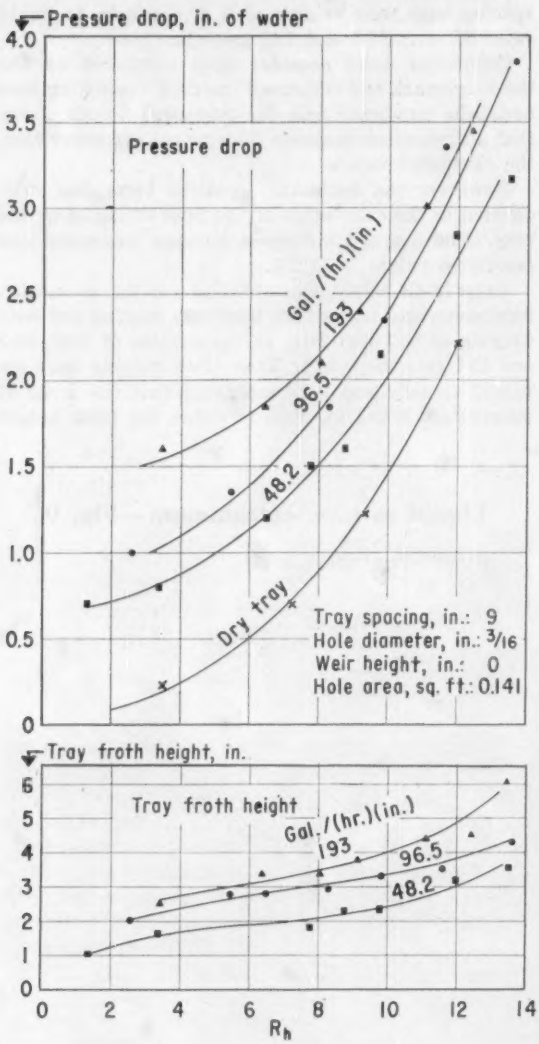
And at another liquid rate—Fig. 8



Liquid rate vs. entrainment—Fig. 9



Effect of pressure and froth—Fig. 10



for a 0-in.-weir tray. It can be seen that froth height increases with increasing vapor and liquid rates.

Conclusions

Results of this study on entrainment from perforated trays at low tray spacings are as follows:

- Quantitative relationships have been obtained giving the increase in entrainment with increased weir height, vapor rate and hole size, and decreased tray spacing and hole area.
- Entrainment increases or decreases with liquid rate, depending on vapor rate.
- Entrainment is not affected by sloping the trays at low vapor rates; however, it is increased at high vapor rates.
- For the trays tested, entrainment is not affected by plate thickness.

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Meet the Authors

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CE Refresher

How to Design Packed-Tower Absorbers

Proper evaluation of mass transfer coefficients is fundamental in establishing height of a transfer unit and number of transfer units for packed-tower absorbers.

JESSE COATES and BERNARD S. PRESSBURG
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Packed towers usually prove to be economically preferable to plate absorbers when the nature of the materials in the system requires corrosion-resistant construction or when the gas flow rate is low.

In general, the minimum diameter for plate columns is 1 or 2 ft., excluding those for laboratory use. Packed towers seldom have a diameter over 3 or 4 ft., although their advocates claim that even larger diameters are satisfactory.

Since the capacity of plate or packed towers is in the order of 5 to 15 moles of gas/(hr.) (sq. ft.) of tower cross section, a satisfactory design can usually be worked out for either type if the flow is in the range of 10 to 100 lb.-moles/hr. Only a cost comparison can determine which type is the more favorable for a specific service. As a rough guide, we can predict that packed units will prove better at the lower end of the capacity range and at all lower flow rates, while plate towers will be more advantageous at the upper end and most higher rates.

In discussing absorbers (*Chem. Eng.*, Oct. 3, 1960, p. 99), we mentioned the general problems of absorber design such as setting the absorbent rate and making enthalpy balances. These fundamentals hold equally for packed absorbers and must be applied in preliminary calculations before the absorber can be sized.

To dimension packed towers, we follow an entirely different and more fundamental approach. Specifically, we must independently evaluate two quantities, the number of transfer units and the height of one transfer unit.

We can best approach and understand these quantities by focusing our attention on a differential slice of the packing which is S sq. ft. normal to the flow of both liquid and vapor and dZ ft. along the path of their flow.

In this differential volume, transfer of solute takes place from the gas to the liquid phase and can be described quantitatively by two equations that give the material balance:

$$d(Vy) = d(Lx) \tag{1}$$

and the transfer rate:

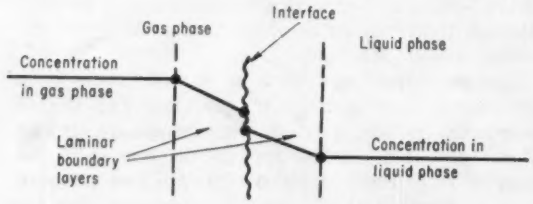
$$dN = K\,dA(c_{gas} - c_{liquid}) \tag{2}$$

Since a change in the solute content of both streams, as expressed by Eq. (1), is the result of the interphase transfer as given by Eq. (2), we may equate them to each other when convenient.

To meet your authors, see *Chem. Eng.*, Sept. 5, 1960, p. 140.

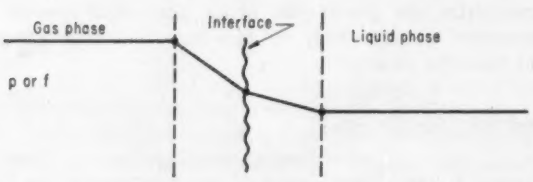
The equation for the transfer rate states that the rate per unit area is the quotient of a driving force and a resistance. As in the case of convective heat transfer, the resistance is expressed in the form of a coefficient. This similarity may be emphasized even further in that its magnitude is determined jointly by the physical properties of the components and by the flow conditions. As in heat transfer, both over-all and phase coefficients may be used.

In heat transfer, the concentration of thermal energy serves as the driving potential, with the only choice one of temperature units. Similarly, the solute concentration is the potential for mass transfer but a much wider latitude exists in the manner in which it is expressed. The accompanying sketch is representative of conditions wherever the gas and liquid are in contact and will illustrate these points.



This representatiion of Whitman's two-film theory is an oversimplification in that no sharp line of demarcation exists between the bulk of the gas phase and the boundary layers. Further, the thickness of the boundary layers is irregular and varies with time. The thicknesses and concentration gradients shown may be considered, at best, statistical and time-average values.

For this sketch, the concentration in both phases is c in units of moles of solute per volume of mixture, or y and x moles of solute per mole of mixture. The absolute values are usually quite different, even at the interface where equilibrium exists. In fact, the numerical values may be higher in the liquid phase even though flow is from the gas to the liquid. We can avoid such apparent inconsistencies if we express concentration as partial pressure, fugacity or similar quantities in which phases in equilibrium have the same value.



The corresponding sketch now shows a continuous variation with position in the boundary layers and no discontinuity at the interface.

Since the rate of solute transfer through unit area dN/dA must be the same no matter which method of expressing concentration is chosen, we can equate these relations. Considering only the gas phase at this point:

$$dN/dA = k_c(c_G - c_i) = k_G(p_G - p_i) = k_y(y - y_i) \quad (3)$$

The subscripts on the coefficient indicate the units of driving force with which it must be used. The three used here are more common but others have been reported in the literature. Since these measures of concentration are interconvertible such as $c = c_T y$ and $p = Py$, the coefficients are likewise interrelated such as $k_y = k_G P = k_c c_T$.

The kinetic theory of gases[1, 2] leads to a theoretically derivable expression for the rate of diffusion through a stagnant gas layer:

$$\frac{dN}{dA} = \frac{D_m(p - p_i)}{Bp_{Bm}} \quad (4)$$

Solving Eqs. (3) and (4) simultaneously leads to the conclusion that $k_G = D_m/Bp_{Bm}$. The symbol D_m is a property of the materials in the system and is readily predictable, p_{Bm} allows for the concentration of the nondiffusing component and B is the thickness of the layer that, in an absorber, is a function of the flow velocities and physical properties of the system.

Since the term B is very small and not directly measurable, correlations in the form of dimensionless groups are necessary here just as in heat transfer. Many have been proposed, of which Eq. (5), for use in a wetted-wall column,[3] is typical.

$$(k_G p_{Bm}/V) = 0.023(dv\rho/\mu)_G^{-0.17}(\mu/\rho D)_G^{0.56} \quad (5)$$

How to Find Transfer Units

Having defined and discussed the coefficient, let's go back to Eq. (2). If we arbitrarily work with the gas phase only and agree to use k_G and partial pressure for the coefficient and driving force respectively, we can now equate the material balance Eq. (1) and the transfer rate Eq. (2) to get the following equation†:

$$dN = d(Vy) = k_G\,dA(p - p_i) = k_G\,dA\,P(y - y_i) \quad (6)$$

Both V and y change but, as shown by Treybal,[4] the quantity of the nondiffusing material remains constant. Thus:

$$d(Vy) = d[yV_{inert}/(1 - y)] = V_{inert}\,d[y/(1 - y)]$$

$$= V_{inert}\left[\frac{(1 - y)dy - y(-dy)}{(1 - y)^2}\right]$$

$$= \frac{V_{inert}\,dy}{(1 - y)(1 - y)} = \frac{V\,dy}{(1 - y)} \quad (7)$$

The area of contact in the differential volume for which Eqs. (1) and (2) were written is $dA = aSdZ$. Here a is area of contact between the phases in sq. ft. of area per cu. ft. of tower volume and is determined by the packing. Incorporating these equalities into Eq. (6) gives:

$$dN = V\,dy/(1 - y) = k_G aS\,dZ(y - y_i) \quad (8)$$

† In this article, we discuss absorption but Eq. (6) and all others apply equally to stripping that differs only in the direction of solute transfer. In stripping $p_i > p$ and $x > x_i$. As a result, the operating line falls below the equilibrium line.

Rearranging Eq. (8) for integration gives this form:

$$dZ = \left(\frac{V}{k_G a S P}\right)\left(\frac{dy}{(1-y)(y-y_i)}\right) \tag{9}$$

According to Eq. (5), the product of $k_G p_{Bm}$ varies as V to an exponent that approaches unity. Since p_{Bm} equals $P\ y_{Bm}$ which equals $P\ (1-y)_m$, the first term on the right hand side of Eq. (9) would be substantially constant if it included $(1-y)_m$ in the denominator. We can introduce it and still maintain an equality if we multiply the numerator by the same value.[3, 4]

$$\int_0^Z dZ = \int_{y_1}^{y_2}\left(\frac{V}{k_G a S P (1-y)_m}\right)\left(\frac{(1-y)_m\, dy}{(1-y)(y-y_i)}\right) \tag{10}$$

Considering the first term constant, Eq. (10) is readily integrated.

$$Z = \frac{V}{k_G a S p_{Bm}} \int \frac{(1-y)_m\, dy}{(1-y)(y-y_i)} \tag{11}$$

The integral on the right is, by designation, the number of transfer units *NTU* and is a dimensionless quantity. Correspondingly, the first term on the right is the height of a transfer unit *HTU* having net units of ft. Therefore, the height of the absorber packing Z is the product of these two quantities, each of which is evaluated independently. Note that *HTU* is a function of gas velocity and fluid properties while *NTU* depends exclusively on concentrations.

Identify Phase for Each Equation

Since our starting balance considered only the gas phase, the specific *HTU* and *NTU* must be so identified as HTU_G and NTU_G. A similar equation can be derived for the liquid phase:

$$Z = \frac{L}{S k_L a c_T (1-x)_m} \int_{x_1}^{x_2} \frac{(1-x)_m\, dx}{(1-x)(x_i - x)}$$

$$= (HTU_L)(NTU_L) \tag{12}$$

If we use an over-all coefficient and driving force, we will obtain the corresponding equations:

$$Z = \left[\frac{L}{S K_L a c_T (1-x)_m}\right] \int_{x_1}^{x_2} \left[\frac{(1-x)_m\, dx}{(1-x)(x^* - x)}\right]$$

$$= (HTU_{OL})(NTU_{OL}) \tag{13}$$

$$Z = \left[\frac{V}{S K_G a P (1-y)_m}\right] \int_{y_1}^{y_2} \left[\frac{(1-y)_m\, dy}{(1-y)(y-y^*)}\right]$$

$$= (HTU_{OG})(NTU_{OG}) \tag{14}$$

To relate these different *HTU*'s, we can go back to the first sketch and write the transfer rate equations, both for the individual phases:

$$dN = k_G a S\, dZ P (y - y_i) = k_L a S\, dZ c_T (x_i - x) \tag{15}$$

and for the corresponding over-all coefficients and driving forces:

$$dN = K_G a S\, dZ P (y - y^*) = K_L a S\, dZ c_T (x^* - x) \tag{16}$$

Solving both parts of Eq. (15) for the potential gives:

$$y - y_i = \left(\frac{dN}{S\, dZ}\right)\left(\frac{1}{k_G a P}\right) \quad \text{and} \quad x_i - x = \left(\frac{dN}{S\, dZ}\right)\left(\frac{1}{k_L a c_T}\right)$$

where y_i is in equilibrium with x_i and $y_i = mx_i + b$. Similarly, y^* is the gas phase concentration that would be in equilibrium with x and $y^* = mx + b$. Hence,

$$y_i - y^* = mx_i - b - mx + b = m(x_i - x)$$

Thus, both phases can be expressed with the same driving force units and may be added, if we multiply $(x_i - x)$ by m in the equation for the potential. This procedure gives:

$$y - y_i = \left(\frac{dN}{S\, dZ}\right)\left(\frac{1}{k_G a P}\right) \tag{17a}$$

$$y_i - y^* = \left(\frac{dN}{S\, dZ}\right)\left(\frac{m}{k_L a c_T}\right) \tag{17b}$$

$$y - y^* = \left(\frac{dN}{S\, dZ}\right)\left(\frac{1}{k_G a P} + \frac{m}{k_L a c_T}\right) \tag{17c}$$

Solving Eq. (16) for $(y - y^*)$ and equating with Eq. (17c) gives:

$$\frac{1}{K_G a P} = \frac{1}{k_G a P} + \frac{m}{k_L a c_T} \tag{18a}$$

By similar treatment of liquid-phase driving force units, we get:

$$\frac{m}{K_L a c_T} = \frac{1}{k_G a P} + \frac{m}{k_L a c_T} = \frac{1}{k_G a P} \tag{18b}$$

The term m, the slope of the equilibrium line, corrects for the different units used to measure potential in the two phases. In this case, dy/dx, the slope of the equilibrium diagram in mole-fraction units would be the correct quantity to use.

If the equilibrium line is straight over the range of concentrations, the over-all coefficient is constant. If not, the over-all coefficient may vary even though the coefficients for the individual phases do not change.

Further mathematical manipulations can convert this relation between coefficients, Eq. (18a), to that between *HTU*'s. For example:

$$\left[\frac{V}{(1-y)_m S}\right]\left[\frac{1}{K_G a P} = \frac{1}{k_G a P} + \frac{m}{k_L a c_T} = \frac{m}{K_L a c_T}\right]$$

$$\left[\frac{V}{S K_G a P (1-y)_m} = \frac{V}{S k_G a P (1-y)_m} + \left(\frac{Vm}{S k_L a c_T (1-y)_m}\right)\left(\frac{L(1-x)_m}{L(1-x)_m}\right) = \left(\frac{Vm}{S K_L a c_T (1-y)_m}\right)\left(\frac{L(1-x)_m}{L(1-x)_m}\right)\right]$$

$$HTU_{OG} = HTU_G + HTU_L \frac{mV(1-x)_m}{L(1-y)_m}$$

$$= HTU_{OL} \frac{mV(1-x)_m}{L(1-y)_m} \tag{19}$$

Thus, if we calculate the phase *HTU* values from accepted correlations such as Eqs. (20a) and (20b), we can combine them into over-all values as convenient. Eqs. (11) to (14) show that all *HTU-NTU* pairs, properly evaluated, give the same packed height.

$$HTU_G = \frac{\alpha(V'/S)^{\beta}}{(L'/S)^{\gamma}}\left(\frac{\mu}{\rho D}\right)_G^{0.5} \qquad (20a)$$

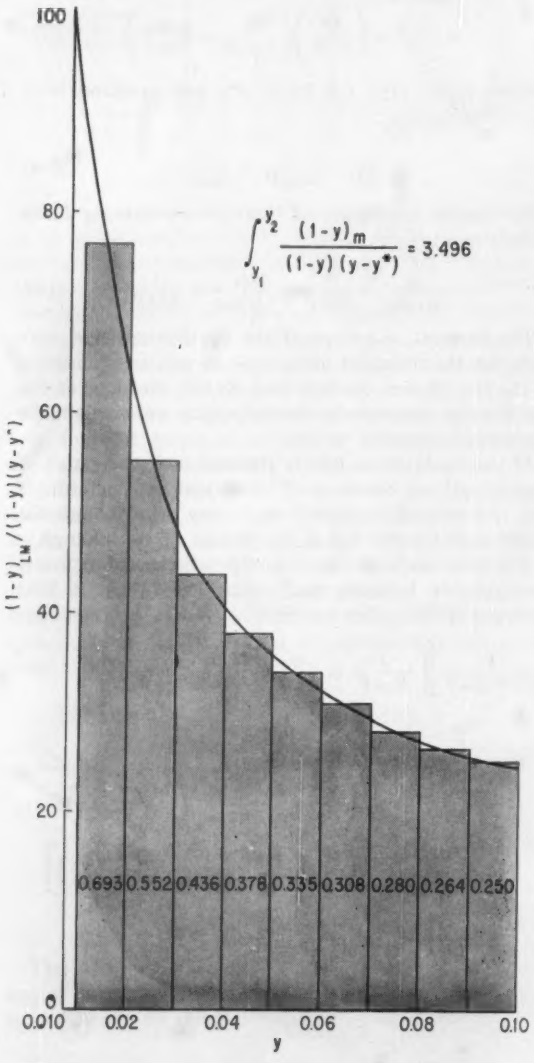
Values for the constants α, β and γ are determined by the size and shape of the packing.[4, 5] For 1-in. Raschig rings, α is 6.41, β is 0.32 and γ is 0.51.

$$HTU_L = \frac{1}{\alpha'}\left(\frac{L'/S}{\mu}\right)^{n}\left(\frac{\mu}{\rho D}\right)_L^{s} \qquad (20b)$$

Values of the constants[4, 6] α' and n are again a function of the packing. Value for s is usually 0.5. For 1-in. Raschig rings, α' is 110 and n is 0.23. Values for other packings are available in the references.

A comprehensive compilation and analysis of the experimental data on which these and comparable correlations are based appeared recently.[7] It includes charts and corrective factors designed to give closer agreement between calculated and observed *HTU* values for both gas and liquid phases.

Fig. 1—Integrate to find transfer units



Find Number of Transfer Units

Over-all *NTU* values are simpler to evaluate. To illustrate one technique, let's determine the NTU_{OG} for the ammonia-air-water separation used to illustrate the determination of *NTP* in an earlier article (*Chem. Eng.*, Oct. 3, 1960, p. 103).

From the operating and equilibrium lines, we choose arbitrary values of x between inlet and outlet, read the corresponding y values from the operating line and the y^* values from the equilibrium line, and make the computations tabulated:

x	y	y*	(1 − y)	(1 − y*)	$(1-y)_m$	(y − y*)	$\frac{(1-y)_m}{(1-y)(y-y^*)}$
0.00	0.0110	0.0000	0.9890	1.0000	0.994	0.0110	91.5
0.02	0.0236	0.0060	0.9764	0.9940	0.985	0.0176	57.0
0.04	0.0364	0.0124	0.9636	0.9876	0.975	0.0242	41.9
0.06	0.0593	0.0207	0.9507	0.9793	0.965	0.0286	35.4
0.08	0.0625	0.0292	0.9375	0.9708	0.954	0.0333	30.5
0.10	0.0759	0.0382	0.9241	0.9618	0.942	0.0377	27.1
0.12	0.0900	0.0493	0.9100	0.9507	0.930	0.0407	25.2
0.135	0.1000	0.0583	0.9000	0.9417	0.919	0.0417	24.5

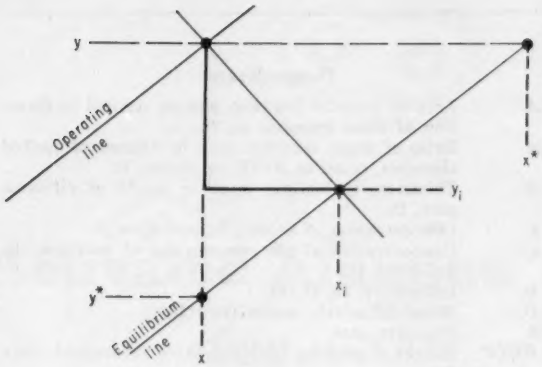
If we plot y against the last term in the table, we get the curve shown in Fig. 1. The area under the curve at any value of y is $[(1-y)_{LM}/(1-y)\ (y-y^*)]\,dy$. Thus, the total area under the curve between $y_1 = 0.011$ and $y_2 = 0.10$ is the NTU_{OG}. This area can be determined in any conventional manner such as by assuming average ordinates for finite increments of y. Proceeding in this manner, as shown in Fig. 1, we find the NTU_{OG} to be 3.50.

In general, the number of over-all transfer units (gas phase) is not the same as, but neither does it differ greatly from, the *NTP* that is 2.75. The *NTU* and *NTP* are equal only in the special case that the absorption factor L/mV is unity, which makes the equilibrium and operating lines parallel. Since practical operation usually requires that the absorption factor be greater than one, it is interesting to note that the *NTP*, in this case, is less than the *NTU*.

If we wish to evaluate NTU_G instead of NTU_{OG}, one modification of this procedure is necessary. We must locate y_i to use in place of y.* To do so, a tie line is drawn as shown in the sketch from y to the equilibrium line with a slope of $-(k_L a c_T/k_G a P)$. This locates y_i and x_i on the equilibrium curve because it satisfies Eq. (15), which can be rearranged as:

$$\frac{k_L a c_T}{k_G a P} = \frac{y - y_i}{x_i - x}$$

To determine liquid phase transfer units, we would use the same basic procedure but would find x and x^* (or x_i) for each value of y. Then, we would make comparable mathematical computations as called for by NTU_{OL} or, NTU_L in Eqs. (12) and (13).



In the special case in which the equilibrium and operating lines are straight—as they probably are with isothermal operation, ideal solutions and low values of both x and y—the quantity $(y-y^*)$ varies linearly with y, and the NTU_{OG} may be evaluated more simply by using the logarithmic mean driving force.

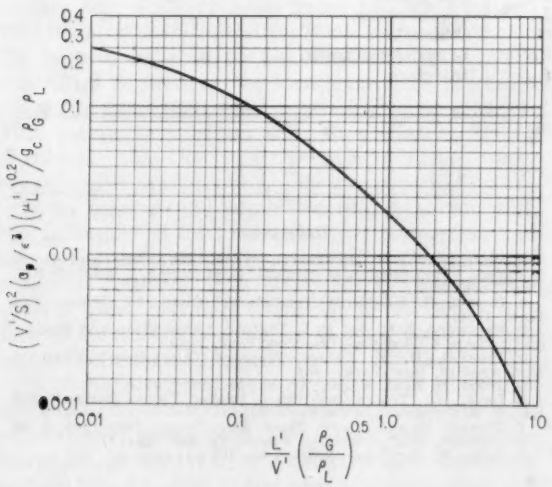
$$NTU_{OG} = \int_{y_1}^{y_2} \frac{dy}{(y-y^*)} = \frac{1}{(y-y^*)_{LM}} \int_{y_1}^{y_2} dy$$

$$= \frac{(y_1 - y_2)}{\dfrac{(y-y^*)_1 - (y-y^*)_2}{\ln[(y-y^*)_1/(y-y^*)_2]}} \qquad (21)$$

Applied to the preceding example, the NTU_{OG} calculated by Eq. (21) is 3.86. This is a fair approximation considering that the lines are not perfectly straight and that y is not completely negligible as compared to one.

Similar expressions could be written for NTU_G, NTU_L and NTU_{OL}. Also, Colburn[5] derived an analytical expression for NTU_{OG} and NTU_{OL} that can be used to estimate the NTU. Its use is restricted to dilute concentrations and linear equilibrium lines.

Fig. 2—Lobo chart gives flooding rate



Determine Operating Velocities

The last quantity needed to complete the design is the velocity or, more precisely, the V/S and L/S that this establishes. From these ratios, we can determine the cross-section area required from the following equation:

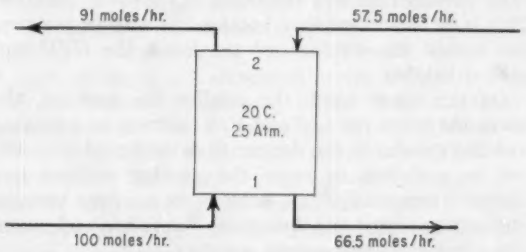
$$S = \frac{V}{V/S} = \frac{L}{L/S} \qquad (22)$$

As shown by Eqs. (20a) and (20b), the velocity also affects the HTU values and, thus, the height of the column. Examination of the HTU definitions and correlations leads to the conclusion that the higher the velocity, the taller and slimmer the column tends to be and the lower the volume of packing. Unless the pressure drop is a significant economic factor, it follows that good design requires as high a velocity as possible. The slenderness ratio (height to diameter), which controls reasonable construction height, is also dependent on velocity.

The upper limit on velocity is determined by flooding that will occur if the gas-phase pressure drop becomes so high, about 4 in. of liquid/ft. of packing height, that the liquid potential head is not sufficient to force downward flow of liquid. Lobo's plot[2] as shown in Fig. 2 is the simplest method of determining the flow rates that will cause flooding. Normal practice is to operate at from 50 to 75% of this maximum velocity.

The following problem shows how to use Fig. 2. Based on the resultant V/S, we can determine diameter, height of a transfer unit and packing height for the separation given in the previous problem.

Let the absorber operate under the conditions given by the table and sketch. Assume viscosity μ' of absorbent and rich liquid is one centipoise and that the packing of 1-in. Raschig rings has an a/ϵ^3 of 164.



	Flow, Moles/Hr.	Flow, Lb./Hr.	Density, Lb./Cu.Ft.	Concentration Mole Fraction
Feed gas.....	100	2,780	0.1805	$y_1 = 0.100$
Residue gas	91	2,627	0.187	$y_2 = 0.011$
Absorbent.....	57.5	1,035	62.3	$x_2 = 0$
Rich liquid.....	66.5	1,188	62.4	$x_1 = 0.135$

Step 1—Determine the flooding rates at top and bottom sections of the absorber. Calculated value of $(L'/V')\ (\rho_G/\rho_L)^{0.5}$ for top section is 0.0215 and bottom section is 0.0227. From these values and Fig. 2, find the flooding rate that equals 0.2 for each section.

Substituting in the expression for flooding rate gives:

$$\frac{(V'/S)^2(a_p/\epsilon^3)(\mu)^{0.2}}{g\rho_L\rho_G} = 0.2$$

and calculate V'/S as 2,440 lb./(hr.) (sq. ft.) for top section and 2,380 for bottom section.

Step 2—Assuming that area is required at 60% of flooding, calculate surface necessary at top section and at bottom section. For top section, required area is 2,780/(2,440 × 0.6) or 1.94 sq. ft.; and bottom section needs 2,627/(2,440 × 0.6) or 1.80 sq. ft. Make column area uniform at 1.94 sq. ft., which corresponds to a diameter of 1.57 ft.

Step 3—Determine HTU_G HTU_L and HTU_{OG} by using Eqs. (20a), (20b) and (19), respectively. Calculate:

$$(L'/S)_{avg.} = 1{,}112/1.94 = 575$$
$$(V'/S)_{avg.} = 2{,}703/1.94 = 1{,}400$$

Then, substitute in Eq. (20a) to get:

$$HTU_G = \frac{(6.41)(1{,}400)^{0.32}}{(575)^{0.51}}(0.61)^{0.5} = 1.98 \text{ ft.}$$

Note: value of $(\mu/\rho D) = 0.61$ from Sherwood and Pigford,[3] p. 20.

Next, substitute in Eq. (20b) to get:

$$HTU_L = \frac{1}{110}\left(\frac{575}{2.42 \times 1}\right)^{0.32}\left(\frac{2.42 \times 1}{62.4 \times 5.2 \times 10^{-5}}\right)^{0.5} = 0.875 \text{ ft.}$$

Value of $D_L = 5.2 \times 10^{-5}$ from Treybal,[4] p. 25.

Compute HTU_{OG} by substituting in Eq. (19):

$$HTU_{OG} = 1.98 + \frac{(0.875)(0.91)}{(1.20)(0.95)} = 2.68 \text{ ft.}$$

Average values for L/Vm, $(1 - x)_m$ and $(1 - y)_m$ are based on previous calculations and data.

Step 4—Compute height of absorber packing Z from NTU_{OG} and HTU_{OG}. Hence, $Z = 3.50 \times 2.68 = 9.38$ ft.

Our *HTU* calculations assume that we have previously specified the size and shape of the tower packing. This is an important item because the smaller the size, the higher the a-value and the lower the *HTU* and packed height.

On the other hand, the smaller the packing, the lower the value for L/S and V/S that can be tolerated and the greater is the danger that the liquid rate will not be sufficient to cover the packing surface and utilize it completely. This latter point has been brought out only recently[8] and does much to explain and reconcile otherwise inconsistent results.

Assuming that commercially available rings or saddles are used, a good rule-of-thumb is that the packing size should not be larger than one-eighth the column diameter.

For multicomponent mixtures, it is necessary to use the *NTP* approach and to translate the results into a packing height by use of an empirical value for the height of packing, equivalent to a theoretical plate, *HETP*. The *HTU* correlations and phase concepts are useful here in correcting from one set of conditions to another but, at the present time, no reliable generalized *HETP* correlations are available.

Nomenclature

A	Area of transfer between phases, normal to direction of mass transfer, sq. ft.
a	Ratio of mass transfer area to volume of packed absorber, equal to A/SZ, sq. ft./cu. ft.
B	Thickness of laminar layer or length of diffusion path, ft.
c	Concentration of solute, lb. moles/cu. ft.
c_T	Concentration of all components of mixture, lb. moles/cu. ft.
D	Diffusivity, sq. ft./hr.
D_m	Molal diffusivity, moles/(hr.)(ft.).
f	Fugacity, atm.
HETP	Height of packing equivalent to a theoretical plate, ft.
HTU	Height of a transfer unit, ft.
k	Mass transfer coefficient, moles/(hr.)(sq. ft.)(unit driving force).
K	Over-all mass transfer coefficient, moles/(hr.)(sq. ft.)(unit driving force).
L	Flow rate of liquid phase, moles/hr.
L'	Flow rate of liquid phase, lb./hr.
m	Slope of equilibrium line.
NTU	Number of transfer units.
P	Total pressure, atm.
p	Partial pressure of solute.
p_B	Partial pressure of nondiffusing components.
S	Cross-sectional area of column, normal to flow of liquid and gas phase, sq. ft.
v	Linear velocity, ft./hr.
V	Flow rate of gas phase, moles/hr.
V'	Flow rate of gas phase, lb./hr.
x	Concentration of liquid phase, mole fraction.
x^*	Concentration of liquid in equilibrium with gas of concentration y.
y	Concentration of gas phase, mole fraction.
y^*	Concentration of gas in equilibrium with liquid of concentration x.
Z	Packed height, ft.
ϵ	Porosity of packing, volume of voids/unit volume of packing.
μ	Viscosity, lb./(hr.)(ft.).
μ'	Viscosity, centipoise.
ρ	Density, lb./cu.ft.

Subscripts

c	Concentration driving force units.
G	Gas phase.
L	Liquid phase.
O	Over-all.
LM	Logarithmic mean.
i	Interface.

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In a letter to the editor, Dr. Dieter Janchen asserts that activated alumina can be used to adsorb water from gases containing unsaturated hydrocarbons. This is in answer to G. S. Cochrane's . . .*

What's Wrong With Alumina?

Low capacity of the alumina is the combined result of two effects. One is the reduced rate of adsorption; the other is reduced equilibrium water capacity.

Since the hydrocarbons must be desorbed before water is adsorbed, the rate of water adsorption is slowed down, resulting in a lower capacity under dynamic conditions. This effect is probably small since changes in gas velocity have very little effect on capacity.

Predominant effect is reduced equilibrium or pseudoequilibrium water capacity due to the presence of hydrocarbons. Cause of this reduction in equilibrium isn't understood. However, it appears it isn't entirely due to polymerization of hydrocarbons on the alumina since there are less than 0.1% unsaturates in the feed gas. In addition, total carbon remaining on a regenerated sample of alumina that had been in service 6 mo. was only about 7 wt. %. (Excerpt from article in *Chem. Eng.*, Aug. 24, 1959, pp. 129-132.)

Activated Alumina for Gas Drying

DIETER JANCHEN

CAMAG Co.

A recent article by G. S. Cochrane[1] reported on the experience gained with a technical gas drying process in which aluminum oxide, used as a drying agent, showed unsatisfactory process life.

We have examined the question of why aluminum oxide showed unsatisfactory performance in this drying application. In our opinion, the reduction in adsorptive capacity results from three causes:

- Coating of the surface by materials that hinder the adsorption of water and that cannot be removed by customary regeneration processes.
- Reduction of the surface area of the aluminum oxide by sintering during thermal stress periods.
- Recrystallization of the aluminum oxide to inactive crystal forms.

Cochrane[1] excludes the first cause as a possibility. His reasoning is that the gases that are to be dried contain only 0.1% of unsaturated hydrocarbons and that the aluminum oxide after 6-mo. use contains only 7% carbon, referred to dry aluminum oxide. The adsorptive capacity of the aluminum oxide showed a reduction from 12.8 to 3.3% water loading capacity. This means that active adsorption centers of the aluminum oxide that would be able to adsorb water are no longer available or are no longer active.

If we compare the adsorption of 7% carbon with the reduction of 9.5% in the water adsorption and take into consideration the space requirements of the adsorbed molecules, it is clear that Cochrane's data actually prove that only a blocking of the active surface by hydrocarbon polymers is responsible for the loss of water loading capacity.

To further support this postulate, we find that molecular sieves remain free from such coverage with polymerized hydrocarbons. The pores of the molecular sieves are of the order of magnitude of 5 angstroms and are thus too small to accomodate hydrocarbons and allow them to polymerize. On the other hand, the pore diameter of aluminum oxide is about ten times this value.

Reduction of adsorptive capacity by sintering of the active surface is probably very small, in view of the investigations of Russell and C. N. Cochran.[2] Sintering of active aluminum oxides takes place only at temperatures above 660 F., to 930 F. These temperatures are not reached in normal regeneration processes.

While it is true that a minimal reduction in surface area may be caused by the temperature stresses in processing, this is not likely to have a sizable influence on water adsorption. In any instance, such capacity losses are not encountered with other drying processes, in which unsaturated hydrocarbons do not get in contact with aluminum oxide.

Addition of water to the crystal lattice by formation of inactive types of aluminum oxyhydrates is not likely to occur. Wohlleben[3] shows that activated alumina, loaded with water to the extent of from 3 to 15%, does not add this water to the crystal lattice.

Removal of the film of polymerized hydrocarbons from the active surface of the aluminum oxide leads to life spans of this gas drying agent that are equal to those of molecular sieves. However, it is of critical importance that these polymers are removed in such a fashion that simultaneous injury to the adsorbing surface does not occur. We have used a method of regenerating the alumina by burning off the films of polymerized hydrocarbons in extremely short time.[4]

Unfortunately, we do not have test results for our aluminum oxide in technical gas drying applications. However, we made stationary tests to ascertain the

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*Dr. Janchen is technical director of the CAMAG Co., Muttenz, Switzerland, where he is working in the development of activated aluminas and processes for their regeneration. He is a graduate of the Technical University of Berlin with the degrees of Dipl.-Ing. and Dr.-Ing.

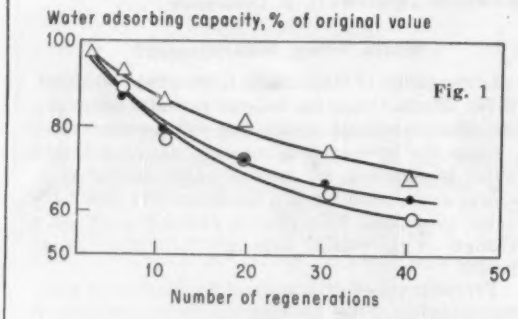

Fig. 1

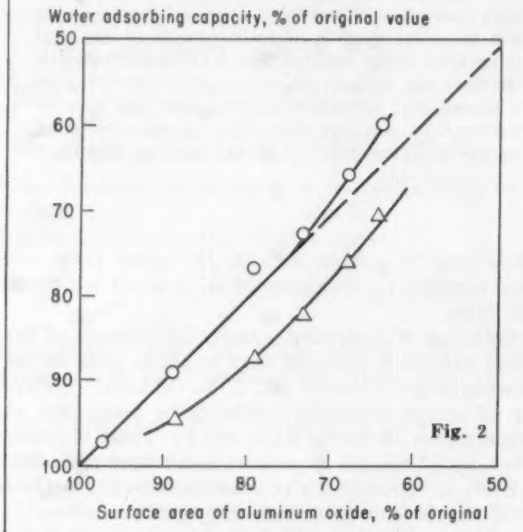

Fig. 2

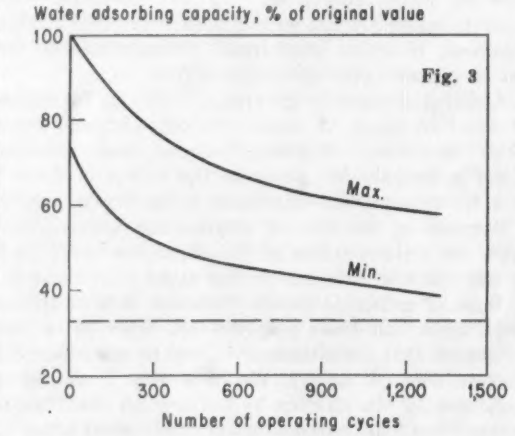

Fig. 3

water pickup of the aluminum oxide by storing it with water at 68 F. in closed containers and determining the amount of water adsorbed after both 5 hr. and 20 hr.

Instead of coating the alumina with hydrocarbon polymers, we soaked it in an 8% solution of an unrefined lube oil (10% unsaturates) in petroleum ether. After distilling off the ether, a 5% oil-load remained.

Then, the oxide was regenerated by burning off[4] the oil, and water adsorption was again measured. In this manner, about 40 regenerations were carried out. The results are given in Fig. 1. The graph shows that the active surface[5] is reduced to 65% of its original value after 40 regenerations and that the water adsorption after 5 hr. approaches this value.

It is interesting to note that the water adsorption after 20 hr. is relatively larger than the available surface area. The results are shown in Fig 2, which relates surface to water adsorption after 5 and 20 hr. The curves would be expected to fall on the diagonal of the diagram. As is seen from Fig. 2, the curve for the 5-hr. water adsorption does so, but the curve for the 20-hr. test does not.

The results indicate that we must differentiate between speed of water adsorption and water adsorption in equilibrium. For technical gas drying problems, the speed of water adsorption is of principal interest. Hence, the 5-hr. curve will be used to apply our results to a practical problem.[1]

Water adsorption capacity of the aluminum oxide used by Cochrane initially amounted to about 12% of the oxide by weight but diminished to 8% after 30 operating cycles. The adsorber charge was useful as long as water adsorption did not fall below a capacity of 4 lb./100 lb. of drying agent. Therefore, we recommend regeneration of the adsorbing agent after 30 cycles. This restores water adsorption capacity of the alumina to 97.5% of its original value. Repetition of such regeneration after every 30 cycles yields the calculated capacity curves for the drying agent shown in Fig. 3.

The upper curve of Fig. 3 represents maximal capacity immediately after regeneration, while the lower curve shows the condition immediately preceding a regeneration. Fig. 3 also shows a dotted line at 33% water capacity that represents the lower limit for perfect functioning of the dryer, according to Cochrane. Note that the minimal curve does not reach this value after 1,500 cycles, so that the useful life of the aluminum oxide in the process presented here is greater than 30 mo.

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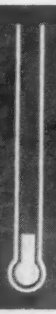
This is the seventh and last in our series of articles on low-temperature construction materials. We discuss and compare the common metals in cryogenic service today. We also discuss briefly the superinsulations that help contain ultralow temperature fluids, and describe some pieces of cryogenic equipment.—Editor



CARBON STEELS
ALLOY STEELS
STAINLESS STEEL
NICKEL ALLOYS
ALUMINUM
COPPER

Low-Temperature Metals: A ROUNDUP

GEORGE H. ZENNER
Linde Co.

Gases, such as oxygen, hydrogen, nitrogen and many others, can be most conveniently handled as cryogenic liquids since they then occupy far less space. Oxygen, for instance, occupies 862 times less space as a liquid than as a gas at NTP; nitrogen occupies 696 times less space, and the reduction in space required for storage of other gases as liquids is similarly great.

While there has always been a demand for cryogenic liquids in some quantities, to serve the needs of modern industry, the growth of the missile industry, with its accent on packing the most into the least space and its great and expanding requirements for cryogenic liquids as fuels, has intensified the demand. And this great increase in demand has spurred the development of better and cheaper methods of producing, storing and handling gases as cryogenic liquids.

Producing and maintaining gases as liquids at temperatures from −100 F. to −452 F. is the main problem in cryogenics. The solution lies in the choice of materials for fabricating low-temperature equipment, coupled with proper mechanical design and efficient insulating materials.

The Low-Temperature Properties of Metals

Ultralow temperature characteristics of metals have created unusual problems in fabricating cryogenic containers and machinery. Certain metals lose their ductility at very low temperatures, which makes them unsuitable for construction of cryogenic vessels.

This loss of ductility is measured by the notched-bar impact test. It is important to use a notched specimen since smooth specimens usually show amazing ductility, even at very low temperatures, whereas a notched specimen will fail in brittle fracture. This phenomenon is sometimes called the "notch-sensivity" of metals.

We generally group the common metals according to the classification of their crystal structures—the arrangement of the atoms in the crystal. Metals with a face-centered lattice generally show no loss of ductility at low temperatures. "Body centered" metals, however, show a marked tendency to brittleness at temperatures below the transition range.

Table I shows the ductility of several metals as indicated by notched-bar impact value. Note the change of value for iron from room temperature to −320 F.

The Oldest Cryogenic Metal

Copper was the most widely used metal for early low-temperature work. Its formability and solderability with soft solder made it first choice for experimental equipment. But when this prior experience with small apparatus was carried over to the construction of commercial equipment, copper's low structural strength became a problem and satisfactory large soldered joints were difficult to obtain.

About the same time that the industry needed larger low-temperature pressure vessels, the copper industry was developing higher strength weldable copper alloys. These alloys, like pure copper, showed no deterioration in quality at low temperatures.

One of the most successful alloys is silicon bronze containing 3% silicon and 1% manganese. Table II compares the properties of this alloy and copper. Besides having greater strength than copper, the alloy also has a much lower thermal conductivity. This property makes the material attractive for connections between warm and cold areas. When cold-drawn, the alloy shows a great increase in tensile strength and yield point while retaining considerable ductility. But the cold-drawn material cannot be welded, since the heat of welding anneals it and nullifies the effects of cold-working.

Crystal structure and ductility—Table I

Metal	Lattice	Energy to break, Ft.-Lb. Room Temp.	−320 F.
Aluminum	Face-centered cubic	19	27
Copper	Face-centered cubic	43	50
Nickel	Face-centered cubic	89	99
Iron	Body-centered cubic	78	1.5

Compare copper and copper-silicon—Table II

Property	Pure Copper	Cu-Si Alloy
Tensile strength, psi	33,000	62,000
Yield strength, 0.5% offset, psi.	8,000	21,000
Elongation, % in 2 in.	50	72
Reduction in area, %	65	75
Thermal conductivity, Btu./hr.-ft.-°F.	227	27

New Al alloy better than pure Al—Table III

Property	Aluminum Alloy 2S	Alloy 3S	5083
Tensile strength, psi.	9,500	15,600	45,400
Yield point, 0.5% offset, psi.	2,500	6,000	21,800
Elongation, % in 4 diameters....	25	43	23
Reduction in area, %	...	81	35
Thermal conductivity, Btu./hr.-ft.-°F.	103	92	60

Aluminum is finding wide use in cryogenics, as alloys improve and prices fall. Though aluminum is easily worked in the cold state, it is not very strong. But new weldable alloys with considerable strength have been developed.

Table III compares one such new alloy, 5083, to commercially pure aluminum alloys 2S and 3S. Note the great improvement in strength of the 5083 alloy.

Strength for strength, the new aluminum alloys weigh about the same as stainless steel and cost somewhat less, as fabricated, when ease of working and weldability are considered. Improved welding rods and techniques now permit even wider use of this material in the process industries.

Welds in aluminum alloys are not as resistant to stress fatigue, where stress reversals are frequent, as might be desired. Unfortunately, while weld strength and other properties may improve at low temperatures, the fatigue limit does not improve. This is a serious limitation since the fatigue strength becomes the design stress considerably below the normal design stress. Therefore, Type 304 stainless is substituted for aluminum where fatigue is an important factor in the intended service.

Carbon and low-alloy steels (not including austenitic steels) have a transition range where the material changes from ductile to notch-sensitive and fails in brittle fracture. Though tensile strength and yield point increase, performance at temperatures below the transition point is generally unreliable. If we could be sure that the material would remain free of notches and stress risers, the high strength of low-alloy steel would be most useful at low temperatures.

Increasing the nickel content in steel lowers the transition range and raises the low-temperature ductility. Increasing the nickel content to 9%, with proper heat treatment, drops the transition range below −320 F. and makes the alloy suitable for cryogenics.

Nine percent nickel steel, specified as Sa-353, has an allowable working stress of 22,500 psi., except where weld metal stress is the limiting factor. But welds made with Inco Rod A have tensile strength well over 95,000 psi. and yield strength up to 70,000 psi. Finished vessels must be stress-relieved by reheat treatment at 1025-1085 F. for two hours or more.

Large-scale tests are planned to prove that satisfactory vessels can be welded from quenched and tempered 9% nickel steel and used in the as-welded condition. Elimination of the requirement for heat treatment will make this alloy a more attractive material for construction of high-pressure, low-temperature equipment.

In the 200-series steels, manganese replaces part of the nickel and chromium of the regular 18-8 composition. One of the better of these alloys has 4% Ni, 15% Cr and 10% Mn. These steels have not been entirely successful but there is reason to believe that further development will provide a material well suited to low-temperature work. We feel that these alloys could be further improved by reducing the carbon content.

Increasing the manganese content of carbon steels tends to reduce the transition temperature. Further, there is an interrelationship between carbon and manganese such that increasing the manganese content makes the steel tolerant to a higher carbon content. Where the Mn-C ratio is 6 to 1 or more, the transition temperature may be reduced to about −50 F. with suitable heat treatment.

Steel Can Be Used for Cryogenic Vessels

Steel, in special forms, can be used at very low temperatures. We use steel in wire form in the prestressed concrete tanks that we use for liquid oxygen. In these tanks, the steel wire is wound around the concrete container under a tension of 140,000 psi. We obtain this tension by drawing the wire through a die while it is being wound around the container.

Drawing reduces the wire diameter from 0.162 in. to 0.142 in. At this reduced diameter, the wire has a tensile strength of 230,000 psi. at room temperature and 300,000 psi. at liquid oxygen temperature.

Elongation of the wire at liquid oxygen temperature is only 2% in 10 in., but test specimens can be bent more than 90° before fracturing if there are no nicks in the surface. The extensive cold-work to which the wire has been subjected causes the grains to elongate so that, even if the wire is notched, a crack will not progress directly across it. Instead, if a notched wire is bent at low temperature, there is a separation in an axial plane at the root of the notch. The unnotched portion bends while the notched part separates and remains straight.

Stainless steel is most in evidence in Linde's Tonawanda shop, but aluminum, copper, and bronze find wide use.

Stainless Steel: The New Cryogenic Material

Austenitic stainless steel is a widely used high-strength material for extremely low-temperature service. Its position is being challenged by aluminum for reasons of economy but there are some features of stainless that make it unique for low-temperature applications.

Austenitic stainless steels, usually of the 18% chromium, 8% nickel type (called 18-8), are malleable and ductile at all low temperatures and have no transition temperature below which brittle fracture can occur.

Straight chrome stainless steels have no special low temperature superiority resulting from their chromium content. Any increase in ductility of such materials results more from grain refinement and heat treatment than from alloy addition. For this reason, all reference to stainless steels in low-temperature work is normally to the 18-8 alloy.

Considerable data have been published on the properties of 18-8 alloy. In cryogenic applications, it has the advantages of high strength, easy formability and good weldability for absolutely tight welds. The low coefficient of thermal conductivity of this alloy keeps the refrigeration losses, through attached supports, to a low value.

One of the most important factors to consider in the selection of a stainless steel for low temperatures is its carbon content. Impact strength at low temperatures is very seriously affected by increased carbon content but where there is less than 0.08% C (Type 304), ductility is such that the material shows better than 15 ft.-lb. on the Charpy test under the worst conditions of heat treatment.

In welds, however, carbon content is not the only factor in obtaining satisfactory ductility. Weldments have behaved poorly when they have been held in a sensitization range (800-1,500 F.). Type 310 alloy is the principal exception to this rule.

Columbium-containing 18-8 alloys (Type 347) are frequently used to avoid intergranular corrosion in zones adjacent to the weld. Such alloys, however, have lower ductility in the weld zone at low temperatures than the low-carbon Type 304 stainless. The latter is therefore preferred.

Opinions vary on whether or not stress relief is desirable. The ASME Code for Unfired Pressure Vessels takes a neutral point of view on stress relief. Accordingly, there are not much data available regarding the effect of heat treatment on stainless steels and stainless steel weld metal.

Piping Is as Important as the Equipment

In most cryogenic equipment, piping is made from thin-walled tubing, usually of any alloy with a low coefficient of thermal conductivity such as 18-8 or copper-silicon bronze. Bends in the tubing normally give all the flexibility needed for thermal contraction or small relative movement between liquid container and casing. In certain missile applications, however, large diameter, short, direct piping is necessary. This situation may require special expansion joints.

Early cryogenic equipment was usually made of copper with soft-soldered joints. Since it was readily available as tubing, copper was used for piping long after the pressure vessels were made of improved materials. Overlapping the mating parts compensated for the low strength of the soft solder. Though high-strength copper alloys of low thermal conductivity were preferred, such alloys could not be soldered.

Copper-silicon alloys, on the other hand, are readily joined by welding or silver brazing. Joints now overlap only ¼ to ⅜ in. so that silver solder can be flowed through to make a pocketless joint.

When the cold liquid vessel is aluminum, piping should be made of some other metal, preferably 18-8, to reduce heat flow into the cold vessel. The dissimilar metal joint must frequently be located in a vacuum space and, therefore, must be vacuum-tight.

Several new methods for joining aluminum to other metals are being developed. The refrigeration industry flash-welds copper and aluminum tubes. The Al-Fin process casts a layer of aluminum on a pretinned part made of some other metal. Copper-clad aluminum can serve as an intermediate part, with aluminum welded to the aluminum part and stainless brazed to the copper part. Sometimes, pure silver can be used as the intermediate alloy.

Insulation Is the Heart of the System

About eight years ago, the best commercially available insulation systems consisted of powders, such as perlite or Santocel, in vacuum. These had an apparent thermal conductivity of approximately 1×10^{-3} Btu./

(hr.) (ft.) (°F.), between −300 and 70 F. Because of the vacuum and very fine particle size of these powders, gaseous conduction is all but eliminated. And recent developments have gone far to eliminate the other two modes of heat transfer, solid conduction and radiation.

We found that over 70% of the total heat that leaked through the coarser, heavier powders, such as perlite, was from conduction through the solids. The remainder of the leakage was through radiation. Since there seemed to be no practical way to reduce this intrinsic solid conductivity, we concluded that it would be more fruitful to opacify the powders to reduce radiation.

We tested numerous powders with reflective and adsorptive opacifiers. Mixtures of specially prepared copper or aluminum flakes and Santocel "A" were found to be the most efficient. A copper-Santocel insulation with a thermal conductivity of 0.22×10^{-4} Btu./(hr.) (ft.) (°F.) has been in production for several years.

But still-better insulations were needed to cope with liquid hydrogen, oxygen and helium. Randomly dispersed reflective flakes were not good enough. So, the search turned to oriented radiation shields separated from each other by low-conductivity fillers. We studied many combinations and developed two very promising insulations.

One is a medium-quality variety consisting of 10 to 20 layers of aluminum foil per inch, separated by three-micron glass-fiber mat. It is a relatively low-density (2 lb./cu. ft.) low-cost insulation with a thermal conductivity of 0.11×10^{-4} Btu./(hr.) (ft.) (°F.) between 80 and −297 F. A higher quality variety consists of 40 to 80 layers/in. of aluminum foil and submicron glass-fiber paper. This is somewhat heavier than the other insulation (4.7 lb./cu. ft.) and more costly, but it has the very low thermal conductivity of 0.025×10^{-4} Btu./(hr.) (ft.) (°F.) over the same temperature range.

Cryogenic Vessels Come in All Sizes

Over the past few years, we have fabricated several thousand cryogenic vessels, ranging in size from 8 to 8,000 gal., for the efficient storage and distribution of liquid oxygen, nitrogen, argon, hydrogen, helium and krypton. There were many practical problems associated with insulating vessels of varying sizes and irregular contours. We now have enough experience to prove that cryogenic liquids are safe and convenient to handle and store.

We can best show the state of the art at present by describing a few cryogenic containers and other equipment:

The standard storage and shipping cylinder for liquid hydrogen contains 150 liters. It stands about 58 in. high, is 20 in. in diameter and weighs 185 lb. when full. Between the stainless inner shell and the carbon steel outer shell is approximately 1 in. of laminar-type insulation. Evaporation loss is less than 3% per day.

The newest transport vessel for bulk shipment of helium was designed and built for the Air Force. A 4-in.-thick superinsulation and a refined load-rod design permit a low-loss travel time of twenty days. The unvented liquid container is of stainless steel and the outer shell is carbon steel. The entire unit weighs 33,300 lb.

High-pressure pumps capable of delivering certain cryogenic liquids at pressures up to 13,500 psi. are now being made. All parts subject to stress are stainless steel. Most important for proper operation is selection of the correct materials for the plunger, liner and piston rings. Since liquid hydrogen and helium possess little lubricating qualities and only provide a sink for friction heat, lubrication between rubbing elements has to rely on the lubricating qualities of the materials in the equipment.

Liner and piston rings of Teflon-impregnated bronze have given good results. Teflon is particularly valuable in oxygen service because of its nonburning characteristics and low coefficient of friction. While the Teflon supplies the lubrication, the bronze matrix serves to conduct away friction heat and prevent cold flow.

Graphitic carbon parts of liquid oxygen pumps wore out very rapidly when the same pumps were used for liquid nitrogen service because the lubricating film that is present on carbon in contact with oxygen is absence in nitrogen. A suitable bearing for liquid nitrogen service can be made from a porous carbon material impregnated with wax. Such parts, however, cannot be used in oxygen.

Despite the many advances made in the past few years, progress in this field is still rapid. But there are many improvements yet to be made in existing methods of handling cryogenic fluids.

Meet the Author

GEORGE H. ZENNER *has been, since 1951, assistant manager of Linde's engineering laboratory at Tonawanda, New York. He has been associated with cryogenics ever since he joined the firm in 1927, after graduation from the U. of Illinois with a B.S. in mechanical engineering. He became associated with cryogenic design and development when Linde embarked on its own program for producing and distributing liquid oxygen, and has directed various projects in this area.*

Mr. Zenner is author of a section of the book "Progress in Cryogenics, Vol. 2." He is a member of Tau Beta Pi, Sigma Xi and Pi Tau Sigma.

Blowcase for Slurries Takes on Modern Guise

This idea for the pumping of slag wool slurries was born in a pilot plant but can be equally useful in full-scale plant operations. Developed to overcome plugging and fiber breakage, it can also be used for non-slurries.

★ **Winner of the August Contest by**
C. E. BILLINGS, LESTER LEVENBAUM and LESLIE SILVERMAN
Department of Industrial Hygiene,
Harvard School of Public Health, Boston, Mass.

During some pilot-plant studies of mineral wool filters to be used in controlling air pollution from high-temperature metallurgical operations, we needed to form a continuous bed of slag wool fibers on a horizontal screen, employing a gravity-fed slurry.

Original procedure, using a centrifugal pump to elevate the 1% slurry of fibers (1 micron in diameter and 1 in. long) led to excessive fiber breakage and undesirable filter characteristics. We also had some difficulty with plugging of the pipe lines. Consequently, we designed the modern version of the blowcase described below, and used it to replace the centrifugal pump.

Our first blowcase, used in the laboratory tests, was made from a 15-gal. chemical drum with a removable cover. Later, when we transferred the original blowcase to the field, it developed a leak and we constructed another, using a 3-ft. length of 15-in. pipe. Except for size, the two were substantially similar in design and operation.

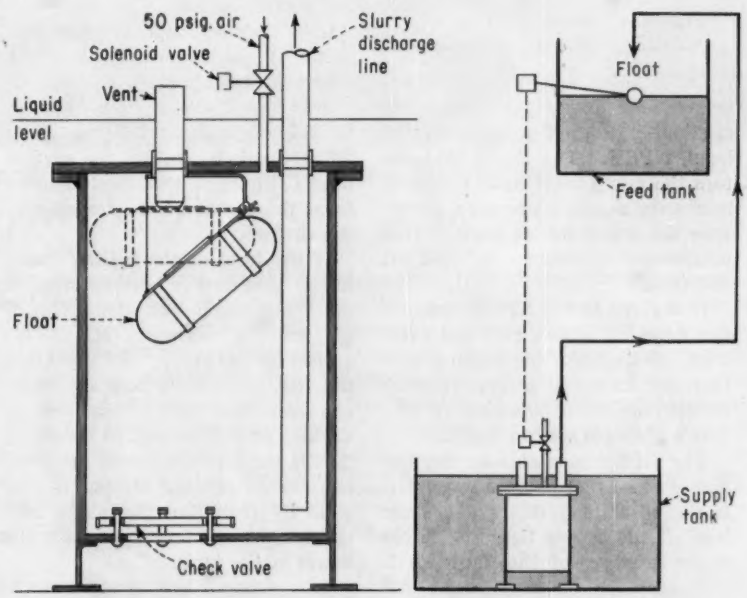
In our initial model, the cover of the drum contained a short length of 2-in. pipe to serve as an air vent. The lower end was machined to act as a valve seat. A hinged valve was actuated by a plastic float (lobster-pot buoy) so that liquid rising inside the chamber would close the vent. The cover also contained the 2-in. slurry-discharge pipe and a connection to a 60-psig. air supply.

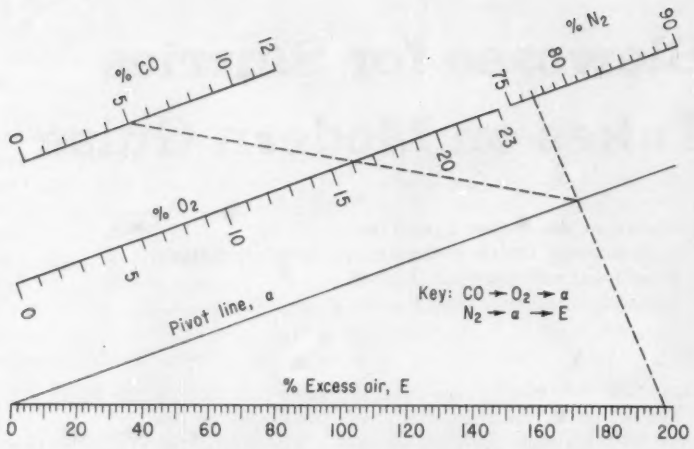
The bottom of the drum was provided with a simple flat-plate check valve. The whole drum was submerged in the supply tank so that slurry could enter by gravity as long as the air vent was open. However, other methods of gravity feed through a similar check valve would also be satisfactory.

In operation, with the drum submerged in the supply tank and compressed air continuously supplied to the chamber, liquid enters through the bottom valve while the compressed air is escaping to the atmosphere through the vent. When the liquid level has risen high enough for the float to close the vent, air starts to pressurize the drum, closing the bottom check valve and forcing the liquid out of the discharge line.

The area of the vent valve is such that the valve will remain closed against the weight of the float so long as there is significant pressure in the drum. However, when all the liquid has been discharged, pressure will be relieved through the discharge line so as to allow the vent to open. Then, liquid will again enter through the bottom valve and the cycle will repeat.

This action continues three to five times a minute—depending on air pressure and pipe resistance—until the level in the overhead feed tank trips a float switch and interrupts power to a solenoid valve in the compressed air line, thus stopping the pumping action.





NOMOGRAPH FOR EXCESS AIR

F. CAPLAN
Kaiser Engineers, Oakland, Calif.

In using an Orsat analyzer to determine the excess air in the flue gases from furnaces and kilns, the chart above gives quick results. It is based on the equation: % excess air = 100 (O_2 − CO/2) ÷ B, where B is 0.264 N_2 − (O_2 − CO/2), and O_2, CO and N_2 are the volumetric percentages of each component in dry flue gas. For example, with 5% CO, 16% O_2 and 77% N_2, the percentage of excess air is 198.

Quick Way of Finding Net Positive Suction Head

M. FRIDMAN
Standard-Vacuum Refining Co.
Altona, Victoria, Australia

In installing a centrifugal pump, one of the important factors to consider is the net positive suction head, NPSH. The liquid that enters the pump must have a certain minimum absolute pressure, otherwise the pump will cavitate. This minimum pressure is NPSH *required.*

In a given pump, NPSH required is a function of flow rate and pressure. Sometimes, the pump manufacturer can supply a curve relating NPSH required to capacity. If not, here's a simple way to find it.

The NPSH *available* in the system is $P - V + L - F$, where P is the absolute pressure above the level of the supply liquid, V is the vapor pressure of the liquid, L is the suction head (negative if there is suction lift) and F is the frictional pressure drop in the pipe.

Imagine a centrifugal pump with the suction bolted directly to the side of an open tank. If the tank liquid is boiling water, then the vapor pressure equals the atmospheric pressure and $P - V = 0$. In this arrangement $F = 0$ so NPSH available equals the suction head L, that is, the vertical distance from the center of the impeller to the surface.

If the level of the boiling water in the tank now is lowered steadily until the pump cavitates, than L will exactly represent NPSH required by the pump. By repeating the test at various pumping rates one can find NPSH required at various flow rates and so construct NPSH vs. flow rate curve. In some cases, even simpler testing is possible by installing the pump vertically and submerged beneath the liquid of the tank.

NEXT ISSUE

Watch for Winner of September Contest

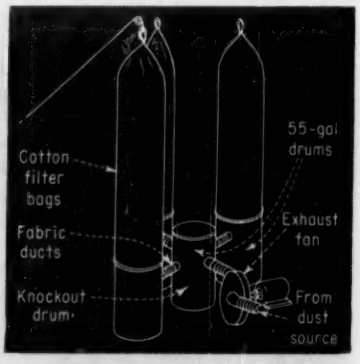
★ How Readers Can Win

$50 Prize for a Good Idea—Until further notice the Editors of *Chemical Engineering* will award $50 each four weeks to the author of the best short article received during that period and accepted for Plant or Process Design Notebooks. Each period's winner will be announced in the second following issue and published in the third or fourth following issue.

$100 Annual Prize—At the end of each year the period winners will be rejudged and the year's best awarded an additional $100 prize.

How to Enter Contest—Any reader (except a McGraw-Hill employee) may submit as many contest entries as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Acceptable nonwinning articles will be published at space rates ($10 minimum).

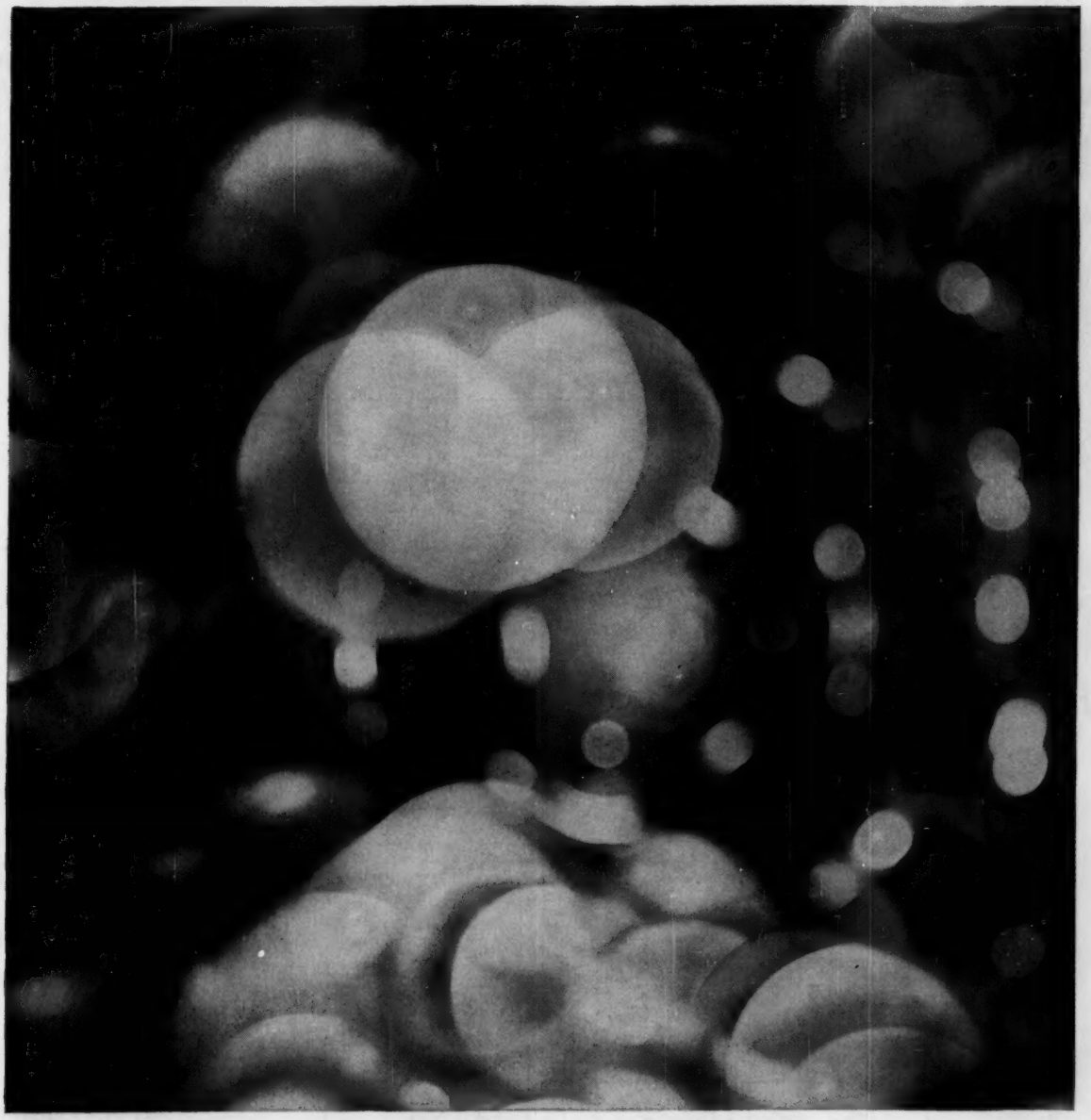
Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant & Process Design Notebooks, *Chemical Engineering*, 330 W. 42 St., New York 36, N. Y.



Temporary Dust Collector Saves Two Months' Time

THOMAS M. SHEETS
Engineering Department
Du Pont Co., Wilmington, Del.

Sketched above is an easily assembled dust collector that we built for temporary use to avoid a two-months' delay in getting a process going. Just before we were to start up a dry-pigment ball-milling operation, the vendor told us the collector on order would be unsatisfactory. The one we put together consisted of an old exhaust fan, motor, 55-gal. drums, wire-reinforced fabric ducts and cotton bags. The collector was installed in an unused area, with the bags held vertical by overhead ropes.



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No. 43: STORAGE AND PROCESS TANKS

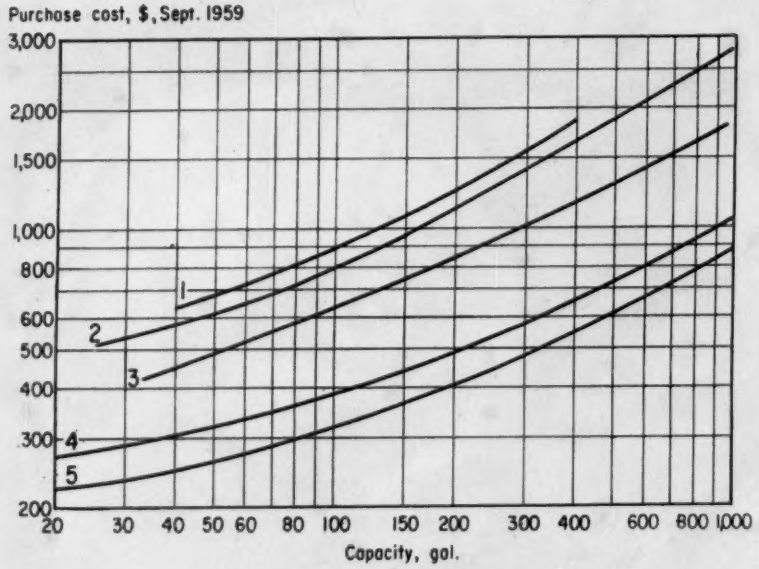
WILLIAM F. WROTH,
The Dow Chemical Co.,
Freeport, Tex.

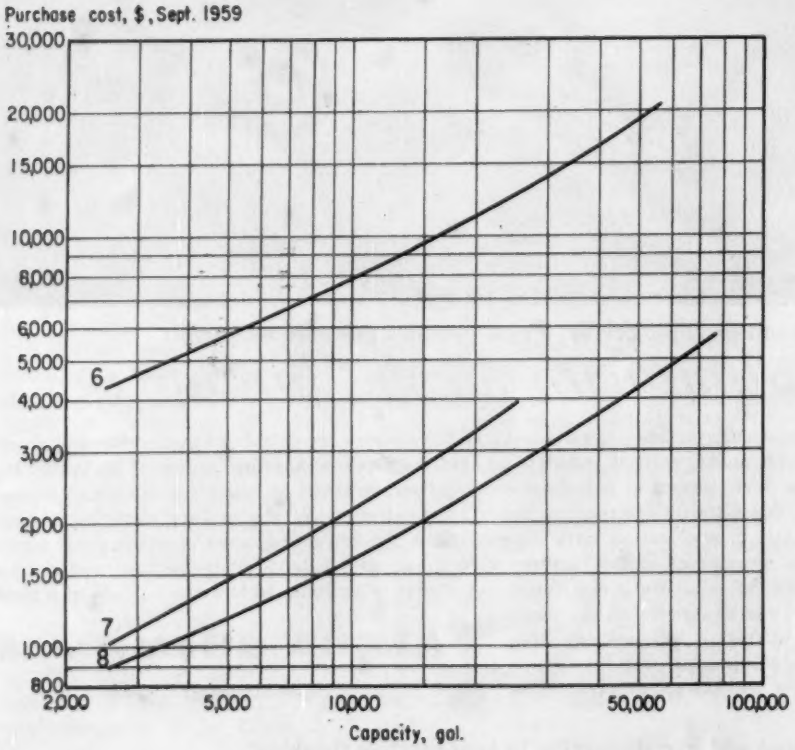
Curves

Tanks are as follows: 1 ss, one end flanged; 2 ss, bumped heads, V-H, process; 3 steel, one end flanged (inhib. makeup C_2H_5 flame arrestors); 4 aluminum, bumped heads, V-H, process; 5 steel, bumped heads, V-H, process; 6 ss, vertical storage including cone bottom; 7 aluminum, vertical storage incl. cone bottom; 8 steel, vertical storage incl. cone bottom.

Factors

For 2-compartment tanks, multiply cost by 1.25; for 3-compartment tanks, multiply cost by 1.35; for 4-compartment tanks, multiply cost by 1.50.





Performance makes the world of difference

Fig. 2453SG—Large Stainless Steel O. S. & Y. Gate Valve for 150 W.P. Fully guided solid wedge disc. Also available with interchangeable split wedge disc — Fig. 2453DG.

Fig. 2433SS — Large Stainless Steel Swing Check Valve for 150 W.P. Bolted flanged cap. Integral seat. Teflon disc and renewable seat ring are available on special order and at extra price.

Fig. 2309—Large Flush Bottom Tank Valve for 150 W.P. Designed for fast draining. Disc opens into tank. Also available with disc opening into valve — Fig. 2310.

Fig. 2107 — Small Stainless Steel "Y" Valve for 150 W.P. Flanged ends, but can be supplied with screwed or socket welding ends. Dimensions conform to latest standards.

To control the flow of corrosive fluids in the most severe services, Powell offers valves that have far greater corrosion, erosion, heat and wear resistance than ordinary valves.

Among the many metals and special alloys in which these valves can be supplied are Stainless Steel, Nickel, Monel Metal*, Hastelloy† Alloys, Ni-resist*, Aluminum, and others to handle the acids, alkalies, organic solvents, and gases encountered in the Chemical and Process Industries.

Just name your valve problem—Powell has the right valve to solve it. For complete information and literature, contact your Powell Valve distributor (there's one in all major cities) or write directly to us.

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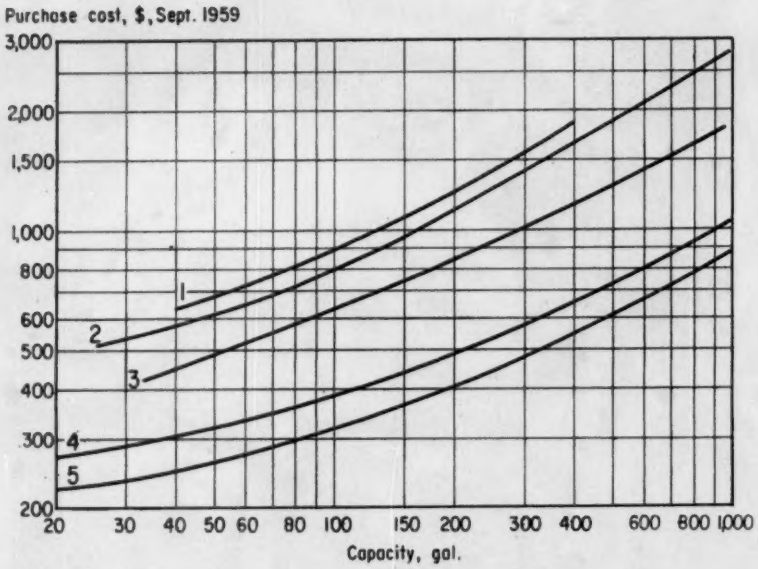
No. 43: STORAGE AND PROCESS TANKS

WILLIAM F. WROTH,
The Dow Chemical Co.,
Freeport, Tex.



Curves

Tanks are as follows: **1** ss, one end flanged; **2** ss, bumped heads, V-H, process; **3** steel, one end flanged (inhib. makeup C_2H_4 flame arrestors); **4** aluminum, bumped heads, V-H, process; **5** steel, bumped heads, V-H, process; **6** ss, vertical storage including cone bottom; **7** aluminum, vertical storage incl. cone bottom; **8** steel, vertical storage incl. cone bottom.

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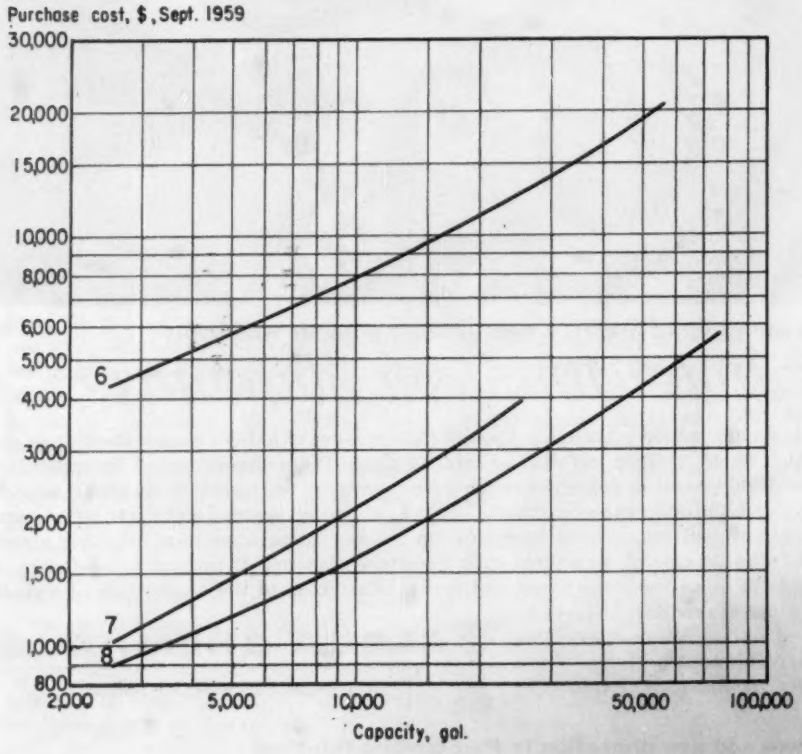

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Personnel are probably the most important ingredient in any new plant startup. But where do you find suitable people? How can you most effectively use those people that you have and those you must add? How can you best train your newcomers? What steps can you take to prevent overstaffing?

Some Thoughts on Staffing New Plants

JACK H. RIDDLE
El Paso Natural Gas Products Co.

Much has been said and written about the mechanics of starting up a new plant, or a new operation in an existing plant, but there is comparatively little to be found about the problems of staffing a plant for startup.

Staffing a plant is not an easy job. There are several groups of people to consider and the approaches to recruitment are different for all. You must also consider the requirements of the particular plant and the people that are actually available to you.

▶**Select Top Management First**—The sooner managerial staff positions are filled, the better future operations will be. And probably the two most important jobs that should be filled at the outset are the positions of plant superintendent and plant engineer—if maintenance is to be under the plant engineer. If maintenance is not to be under the plant engineer, then the maintenance superintendent should be appointed first. Other positions, such as assistant superintendent and plant or maintenance engineer, as applicable, should be filled as soon as practicable.

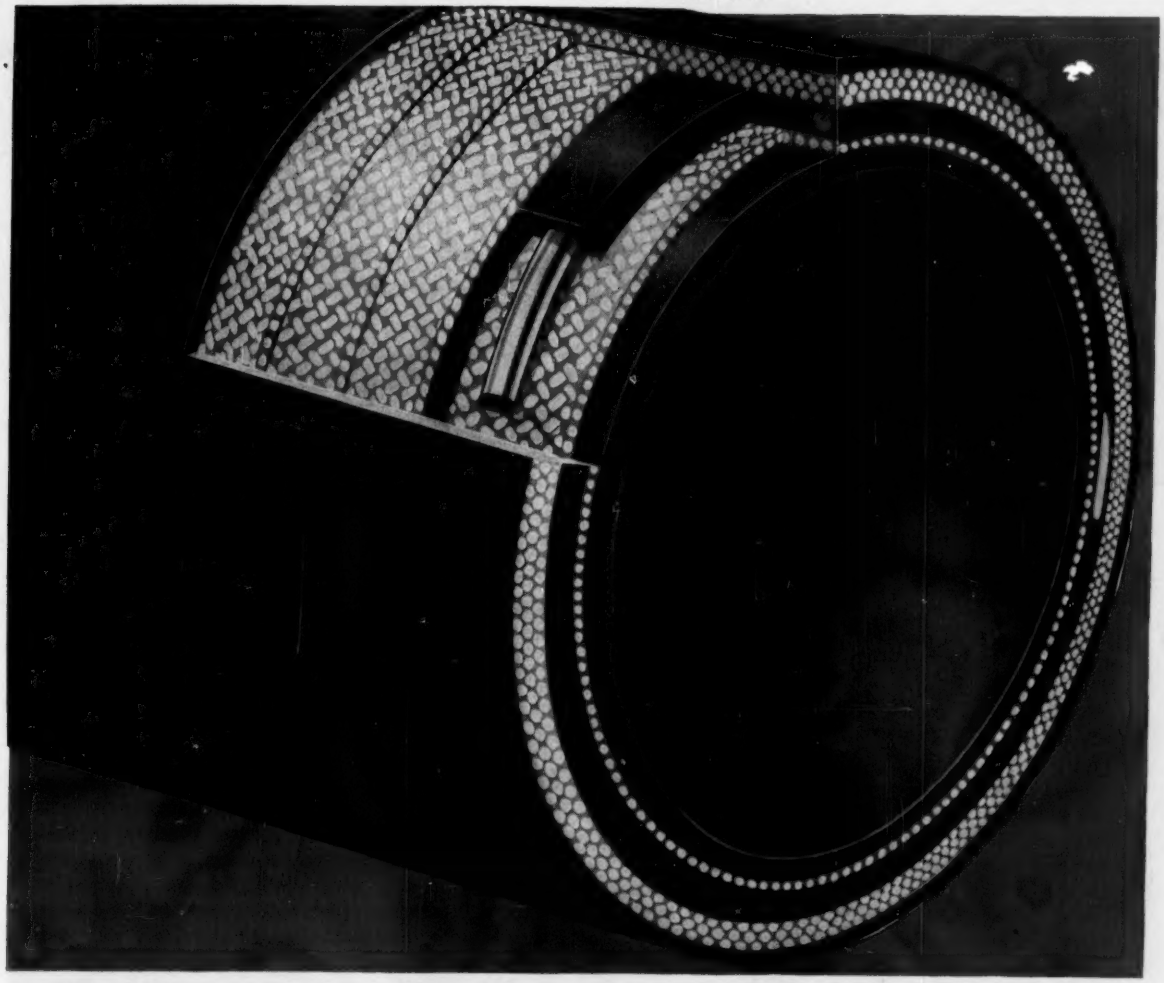
When staffing the new plant at the operating or waged levels, you should use company people wherever possible. Of course, if the new plant is some distance from existing company plants, there will be problems associated with moving the men and their families. But if assignment is based on ability rather than seniority, there may be sufficient incentive to balance these problems of moving.

There must be quite extensive counseling of your employees at this stage of planning. Before moving to the new location, they should have a thorough knowledge of the local municipality, educational, sports and recreational facilities available, and, finally, climatic conditions to be expected. Each man must carefully consider these facts and how they might apply to him and his family. He should also realize that if he moves to the new site, he will most probably lose his seniority rights at the old plant.

▶**An Opportunity for Promotions**—New plants also require filling of salaried positions. Full consideration should be given to company hourly people who might be able to fill these positions. Again, if possible, the company should make the assignments without regard to seniority. But, generally speaking, those most qualified will normally be those with greatest seniority.

Those jobs and positions that cannot be filled with company personnel must be filled by outside hiring.

There are many ways to contact outside people. The personnel



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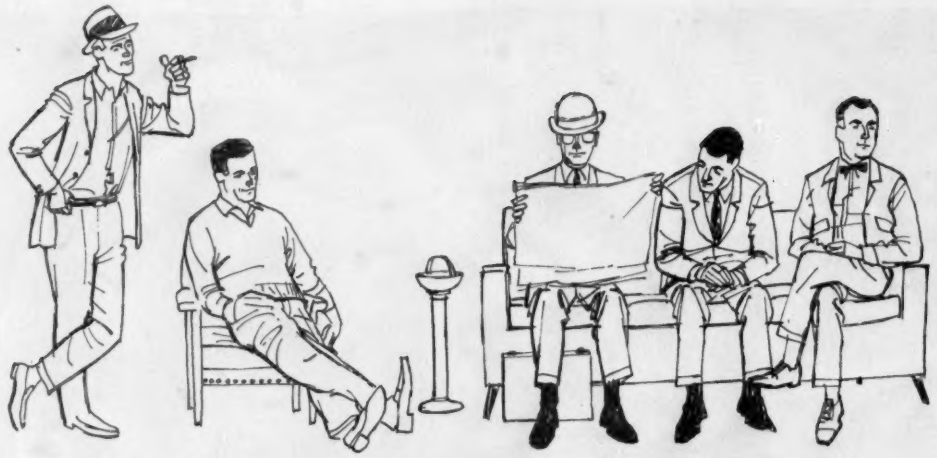

PERSONNEL

department should have a backlog of applications on hand. You should advertise in the local newspapers and other advertising media, such as professional journals. Outside people, however, should be carefully screened. Minimum educational standards, for instance, will automatically eliminate a large number of unsuitable applicants.

You can staff the operating group in a new plant with people who have not had direct experience in the process. So long as minimum educational standards are met and an adequate training program set up, there will be no real difficulty in staffing with a group that can operate the plant at top efficiency.

Other plant personnel, such as those in maintenance, safety, materials handling and all other auxiliary occupations, should be selected in much the same manner as that outlined above. But there is another source of personnel we have not discussed—contract maintenance.

▶**Use Contract Maintenance**—In contract maintenance, certain plant functions are lumped together, labeled "maintenance" and contracted out to contract maintenance firms. These contractors, of whom there are many, will furnish services varying from many highly skilled engineers to a few laborers.

Contract maintenance is a valuable adjunct to a plant startup. If you are not sure of the number of people needed for the operation, for the laboratory or for maintenance, contract maintenance can help. A contractor will furnish helpers for the uncertain positions, who can be used during and after the startup with a minimum of training.

If after operating for some time, you find that you have surplus personnel you just let the contractor know that you no longer need them. What to do with them then becomes his problem, not yours.

But if you find that the jobs need to be continued, you can hire the workers from the contractor. Normally, such people are young and eager to go to work in a new plant. It is very easy to screen them and you have plenty of opportunity to watch them in action before offering a job.

Number of people required on the operating staff of any plant depends on a number of factors. Sometimes, safety dictates the needs. For instance, two men may be assigned to a shift, where one is enough to do the job, so as to provide help for each other in case of an emergency. Or the size of the entire staff may be based on the maximum requirements for handling a fire or major plant upset.

Some people feel that the fire brigade should not be the responsibility of the operators since they will be busy with other duties during a fire or explosion. They will have to keep the process running, or shut it down as the situation may require. However, it might be possible to release certain employees for fire brigade duty while a few key personnel remain at their posts to handle essential operations.

In many plants, the operators seem to spend a good deal of their time in the control room when they are not making their rounds in the plant. Should these people be asked to do janitorial work in that part of the plant to which they are assigned? Such work will keep them busy and perhaps help to instill a certain pride in their plant. But some people feel that they are in the plant only to operate it.

▶**Design for a Minimum Staff**—The modern plant requires a minimum number of people to operate it when it is running correctly, but needs many people when something goes wrong. The operating staff should be reviewed during process and mechanical design, to determine the best balance between actual operating needs and emergency requirements.

With the dependable instrumentation available today to the plant designer, there is no reason why the operating staff should not be kept to a minimum so that investment and/or production per man should be a maximum.

In line with the advances in technology in newer plants, there should be more effort toward developing more technicians who would be paid blue/white collar wages to fill plant jobs. Plants are developing faster in technology than the technical ability of the people who run them on an hour-by-hour basis. During

design of the plant, you should also keep in mind the possibility that operations may become more and more automatic in the future. Consequently, operators should be developed who will be capable of handling the plant as it evolves.

Do not overstaff in anticipation of large personnel requirements for the shakedown phase. It is easy to fill operator jobs, but later on, when you find that the jobs are surplus, it can be very difficult to displace the people filling them. Actually, the plant should be staffed to some level that is less than the minimum required for actual operation. A contractor can then supply any additional temporary personnel that might be required.

Another group of people that you must consider during plant startup is first-line plant management. This group would include shift supervisors, process superintendents, area supervisors and other first-line supervisory personnel.

Such personnel will be quite busy during the startup since they will have to learn more than anyone else in the plant, and in less time. You should use your engineers as area or unit supervisors during startup so that the permanent supervisors will be relieved of routine startup tasks and will be able to devote full time to plant design.

▶**Get the Most from Your Engineers**—We cannot overemphasize the importance of making optimum use of your engineering personnel during a plant startup. The advantages are many. The engineers gain a first-hand knowledge of the plant, get to know the contractor's people, learn how to work with operating personnel and gain supervisory experience. They also get to know the plant supervisory personnel and higher echelons of management, which may stand them in good stead later in their careers.

Assigning your engineers as startup superintendents is an excellent way to increase their responsibilities and help them grow in their jobs. It is also a good way to assure liaison between company personnel and the contractor.

If a process contractor is furnishing startup people, he will normally assign a chief to each unit, to whom the shift process workers will report directly. The unit chief, in turn, will report directly to the startup process superintendent. In this situation, it often pays to assign a company engineer to share the responsibility of the unit startup, the company engineer reporting directly to a startup coordinator or the plant superintendent, as applicable.

This arrangement results in a kind of committee management that can do more harm than good. However, if the people concerned get along well together, this system can work very well. It provides a sort of check and balance between the company and the contractor. A good company engineer on the site, in the unit, can effectively evaluate all contractor actions and requests and make meaningful reports and recommendations on them to management.

Engineers belong to the operations department during and immediately after the startup. No matter what their normal position is in the company, all their activities must be subordinated to the startup and, for a short period, they must consider themselves as part of operations and act accordingly.

First-line supervisors should work with the contractor's staff on the site so that they will be able to operate the plant effectively after the contractor turns it over to the company. Much time should be spent in discussion of expected problems in the plant, data that should be accumulated and both normal and emergency shutdown procedures. The contractor and company operating personnel should also discuss safety procedures applicable to the particular plant. These safety procedures, of course, would not supersede the company's regular safety program.

▶**Proper Training Is Essential**—Now that we have given some thought to procurement of a staff for our new plant, let us talk about training.

Everyone should continue to study throughout his productive life. This is as true for operators as it is for professional engineers. But where the professional engineer requires little guidance and will be most likely self-starting and self-sustaining in his further pursuit of knowledge, the operator will need considerable help and guidance. When should the operators study? Should they attend classes after work or during working hours and how should a study program be initiated?

My company recently began a training program for all operators. The program is entirely voluntary, no one is required to take the course. The course, which is concerned with the fundamentals of the process industry, is designed for shift workers only and is provided for their self-improvement. Classes are so arranged that the men may study on company time during their regular shift work.

The first three study courses issued cover the following subjects:

- Petroleum hydrocarbons.
- Temperature and heat.
- Transmission of heat.

Our reasons for instituting this study program are many, but among the most important is the feeling

that adequate training increases the efficiency of the plant operators and leads to better over-all production. Also, this additional training will help to qualify these people for better jobs with greater authority within the company.

Some people feel that there must be some immediate reward for devoting time and effort to such a voluntary training program. They react with: "What's in it for me?" In our case, successful completion of the course is entered in the personnel record. That is all. However, successful completion of any training courses offered will weigh heavily in the selection of people for staffing a new plant. Also, it is inevitable that completion of such courses will play a large part in any promotions from waged to salaried jobs.

► **Old People Teach New People**—Company people brought into a new plant should already be trained and in a position to act as instructors while giving basic training to new people. The basic outlines of the course they might teach would be as follows:

Classroom work should start with fundamentals such as basic mathematics, chemistry and physics. Such a basic course will serve to pinpoint those people who should either be released or given more basic training, as individual cases may dictate. But the main purpose of these basic studies is to provide a background for later, more advanced courses such as heat transfer.

Later phases of training should be specific to the plant in which the operators will work. You should first cover plant layout, including a discussion of the "why" of such a layout. This is also a good time to discuss the economics of proper layout and design.

From plant layout, you should go to discussion of the various processes involved in the plant. Basic fundamentals of these processes may be taught on a day-by-day basis, as they become necessary to the understanding of the plant. This portion of the training should automatically cover raw materials, handling of intermediate products and, of course, finished products.

While the various processes are being covered, the mechanical aspects of the plant should also be studied. The trainees should be instructed in the basics of heat exchange, furnace design, pumps, and other physical portions of the plant, as the need arises.

Following these discussions on unit operations and processes, the particular equipment installed in the plant should be studied. While a good deal of information on equipment is available from manufacturers' literature and technical manuals, field trips are also essential.

By this time, field trips should supersede classroom work as the trainees become more and more involved in actual construction of the plant. The trainees should see and inspect, internally and externally, every piece of equipment. They should trace lines and know the location and purpose of all important valves. They should also know the name, number and purpose of all vessels, pumps, drives and heat exchangers.

Final formal work should include consideration of all offsite facilities such as tank farms, shipping and receiving facilities, cooling towers, boiler plants and other pertinent installations.

► **To Sum It All Up**—In conclusion, we might make a few brief points concerning the sources of a new-plant staff and its training:

1. Use your own people if possible. To be sure, there are plenty of good people available from any labor pool who will prove to be valuable employees after proper orientation and selection. But, if it is at all possible, it is still best to staff your new plant with people from your existing plants.

2. Get the operating people in on the design and construction phases of the new plant. They will often have many good ideas that will save you money later during operation of the plant.

3. Spend a lot of time training your operators with emphasis on fundamentals, mathematics, physics and chemistry.

4. Plan your startup. Publish a schedule and do all you can to stick to it.

5. Use your engineers. It is a good opportunity for them to get to know the operators and the operations management people. If you are short on well-qualified operations people, assign the engineers to various portions of the new plant during startup. Give them responsibility and authority.

6. Plan a formal training program for your operators. This program should be continuous, not confined only to the plant startup period. It should be designed to help prepare your people for later positions of authority in your company.

Meet the Author

JACK H. RIDDLE *is a graduate of the University of New Mexico from which institution he received his B.S. in Chemical Engineering in 1950. He first worked for Malco Refineries, Inc., at Roswell and Artesia, N.M. In 1954, he went to work for El Paso Natural Gas Co. as process engineer, later transferred to El Paso Natural Gas Products Co. as engineer and is now chief, technical services.*

Mr. Riddle is a member of AIChE and a professional engineer registered in New Mexico. He is presently on the publications board of the New Mexico Professional Engineer.

Score Your Executive Attributes

What attributes differentiate men in executive positions?

Do they have specific habits, attitudes, personality traits?

Can you aid your own progress as a manager or executive?

RICHARD S. SCHULTZ *Industrial Relations Methods, Inc.*

As a result of diverse consulting experience and research with business and industrial organizations, it's now possible to give reasonably sound answers to the three questions listed above.

In this article, we first present an executive qualification guide (what the man should bring to the job) and then a chart of essential attributes of a manager at work (how he should realistically perform on the job).

What Are the Man Specifications?

Men who attain executive positions today are likely to be members of a choice group. It's estimated that out of 100 college graduates probably a range of from 2 to 10, in any particular company, may be potential candidates for top-level executive positions.

To illustrate the qualification demands for managerial responsibility, a succinct list of nine major factors is given below as a special guide.

These specifications are being used effectively by business firms today to appraise experienced or potential executives under consideration for employment. The specifications provide a systematic guide for distilling a miscellany of information about a man's background, experience, ability, personality, motivation and interest.

Careful scrutiny of the guide further clarifies and substantiates the fact that successful executives or potential candidates are a distinct group of men. They can be identified with a reasonable degree of accuracy by appropriate use of the guide.

Regardless of age or experience, such a "blueprint" or list of specifications can be helpful to an individual as a means for reviewing his own personal progress, development and improvement needs for executive responsibility.

Attributes of Managers at Work

If a man has been properly selected for an executive or managerial position, then what tangible characteristics can we notice by watching him at work? We've shown the answers in the form of a self-rating chart.

In the chart on p. 132, we are focusing our attention on the "image" of the executive. He may be an "organization man" or an "entrepreneur" in the same or different companies.

Each of the 20 attributes listed recurs in varying degree—either as an asset or a liability—when appraising men at work in managerial positions or con-

What the man must bring to the job

Diversified abilities and information demonstrated in dealing successfully with problems that involve basic ideas, people or business, such as: sales, accounting, purchasing, production, shipping, warehousing, mechanical, product research or development, special technology, administrative techniques, personnel and labor relations or general management situations.

Personal relations aptitude. Includes such characteristics as: appearance, manner, energy, self-reliance, self-control, initiative, persistence, enthusiasm, sense of humor, forcefulness, confidence, likes to make prompt decisions, "wears well" with people.

Integrity and character consist of all those qualities about an individual and his background that determine dependability, honesty and trustworthiness.

Mature ambition in terms of a sensible self-perspective. Background, experience and activity show a consistent effort by the individual toward self-improvement and growth in accordance with his qualifications; he likes to assume varied or difficult responsibilities.

Stable background, as reflected in family situation, home life, social-recreational activity and financial status.

Communications skill, as revealed by effectiveness or persuasiveness in conveying ideas and information in personal contacts and in writing.

Service attitude, as indicated by consistent effort to anticipate what needs to be done, helping others, prompt and diligent followup to assure success and good will.

Success aptitude, as shown in past and present record of capacity to succeed and make progress in education, training, work and social-recreation-leadership activity.

Managerial skill, as demonstrated by ability in analyzing, planning, organizing, controlling, improving, getting daily results, making effective decisions; and the strengthening of particular functions or operations in accordance with requirements for future company growth.

sidering them for appointment or promotion to other administrative positions.

Essence of the technique, presented in the self-rating chart, is in its personal value to a man. The chart can be used as a realistic and thought-provoking guide by any individual, regardless of his level of experience or responsibility on the ladder of progress in management and leadership. After analyzing the test results, the man can write his own prescription. He can plan to use his assets and overcome his liabilities.

It's apparent that a particular combination of these attributes may be more desirable for one man than for another. This is especially so when an executive

STOP! To derive greatest benefit, take test below before you turn the page.

Essential attributes of managers at work

Check answers that reflect your present job performance ▶	Code (See Text)	Yes ▼	No ▼	Doubtful ▼
1. **Goal directed.** Job performance is guided by goals or objectives based on careful planning, schedules and budgets	(m)	☐	☐	☐
2. **Discriminative action.** Continuously displays sound judgment by setting time priority or sequence on what needs to be done in attaining daily and long-term objectives. Knows how to keep a practical balance between important matters and the details	(m)	☐	☐	☐
3. **Problem solver.** Daily job tasks are regarded as an opportunity for finding solutions to problems. Difficulties or obstacles affecting conditions of business, people and organization are merely the grist of personal challenge	(m)	☐	☐	☐
4. **Urgency drive.** Consistent action directed toward getting things done and attaining measurable results, now—not tomorrow	(d)	☐	☐	☐
5. **Policy-guided.** Thinks and acts according to policy of company, rather than impulse or pressure. Plays according to the "script"	(a)	☐	☐	☐
6. **Team worker.** Achieves results by working cooperatively as part of the management team, not as a "prima donna" individualist	(t)	☐	☐	☐
7. **Sales minded.** Habitually uses sincere persuasiveness and effective communications (spoken or written) in all contacts with people	(t)	☐	☐	☐
8. **Skillful delegator.** Decides what tasks can be assigned to others and uses people effectively	(s)	☐	☐	☐
9. **Time conscious.** Always regards own time and that of others as precious	(s)	☐	☐	☐
10. **Personnel developer.** Helps others grow. Guided by idea that in developing others you develop yourself	(a)	☐	☐	☐
11. **High motivation.** Works hard to get results and opportunity to use fully his capabilities, regardless of any immediate personal reward	(d)	☐	☐	☐
12. **Progress attitude.** Daily personal manner portrayed by optimism, enthusiasm, initiative, action, constructive thinking, cooperation, praise and encouragement	(d)	☐	☐	☐
13. **Self-critical.** Customarily acts as his own severest critic, and responsive to constructive criticism and suggestions from others	(m)	☐	☐	☐
14. **Empathy.** Sympathetic and receptive to viewpoint of others. Can easily place himself in the "other man's shoes"	(t)	☐	☐	☐
15. **Sense of humor.** Seldom loses perspective. Avoids taking himself too seriously. Knows that a smile can help smooth daily friction and win cooperation	(t)	☐	☐	☐
16. **Emotionally resilient.** Practices good self-control. Doesn't let worries develop into an emotional "hangover"	(t)	☐	☐	☐
17. **Growth minded.** A strong desire expressed in steps taken to improve, develop and grow with training, experience and responsibility	(d)	☐	☐	☐
18. **Objective.** Responds to facts and information impersonally and logically. Avoids rationalization, wishful thinking, faulty personalized alibis	(m)	☐	☐	☐
19. **Perspective.** Without neglect of today, keeps tomorrow in sharp focus. Constructive and flexible imagination for future planning	(m)	☐	☐	☐
20. **Result-getter.** "Batting" average shows repeated record of successful performance measurable by profit-and-loss figures. Mere effort without result is regarded as a significant failure	(s)	☐	☐	☐

For answers, see page 134.

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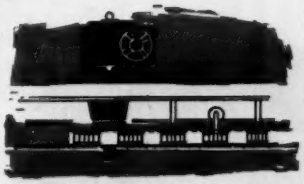
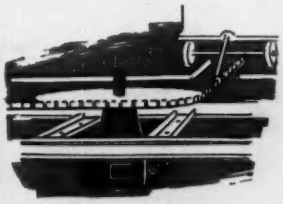
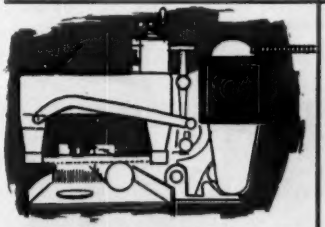


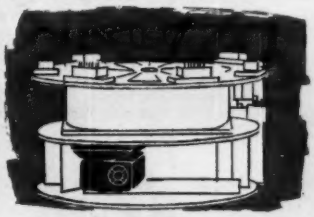
OVERHEAD . . . typical caterpillar or sprocket drives



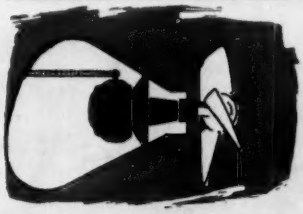
SUB-FLOOR . . . for towline or special equipment



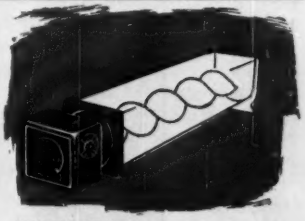
90° MOUNTING . . . for heavy-duty metal saws and machines



VERTICAL . . . base mounting for power turntable machines



SIDE MOUNTED . . . paint, pulp, liquid, or chemical agitators



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Mounting versatility with the unit's cast-in base makes Morse drives adaptable to conveyors of all types, agitators, screw conveyors, machines, and for any other transmission of power where dependable speed reduction is specified.

You'll find Morse "standard" drives ready for immediate delivery . . . often eliminate the problems of "specials." Check with your Morse distributor, he's listed in the Yellow Pages under "Power Transmission," or write Morse Chain Company, Dept.42-100,Ithaca, N. Y. for illustrated catalogs. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario.

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thinks of himself in relation to his organization, function and level of responsibility.

A man can improve himself most readily by making fullest use of his most favorable attributes, rather than trying to superimpose qualities that do not mesh or fit his true self. And he should not mislead himself by thinking that he can change his basic personality.

Essentially, a man should work diligently to acquire (or learn) the right combination of attributes that will assure his most effective performance in an executive or leadership responsibility.

The ultimate and practical answer as to success of a man in an executive or managerial position is judged by his effectiveness as an individual. American free enterprise relies on men who have *substance* as entrepreneurs, executives and leaders.

To illustrate this in an emphatic way, note whether you have circled "Yes" in the self-rating chart on most of Items 2, 3, 11, 16, 18, 19 and 20.

These attributes are the *substance:* discriminative action, problem solver, high motivation, emotionally resilient, objective, perspective and result-getter. They make an executive valuable to a company in terms of contribution to its success, growth and competitive survival.

Now, review the remaining, 13 items. Observe how you checked them for yourself. These attributes portray merely the *form* or manner in which an executive works. Without the seven attributes of *substance,* we may have only a congenial, security- and comfort-seeking organization man. The *form* without the *substance* is what limits development of individual men and the success or growth of their companies.

As a final suggestion about use of the self-rating chart, for personal development, you'll note in front of the answer spaces the letters *m, d, s, t* and *a*. These identify attributes classified as: mental, drive, skill, temperament or attitude. By carefully examining the answers to each of the 20 items, a man should be able to decide wherein he has strength or need for improvement.

It's quite important to note that attributes of *form* may help a man obtain a position. But his length of service and value in a particular organization will ultimately be determined by his attributes of *substance.*

Answers to checklist, p. 132.

Fold page back for comparison

Item No.	Yes (Substance)	Yes (Form)	Attribute Group
.... 1.		√	Mental
.... 2.	√		Mental
.... 3.	√		Mental
.... 4.		√	Drive
.... 5.		√	Attitude
.... 6.		√	Temperament
.... 7.		√	Temperament
.... 8.		√	Skill
.... 9.		√	Skill
....10.		√	Attitude
....11.	√		Drive
....12.		√	Drive
....13.		√	Mental
....14.		√	Temperament
....15.		√	Temperament
....16.	√		Temperament
....17.		√	Drive
....18.	√		Mental
....19.	√		Mental
....20.	√		Skill

Meet the Author

RICHARD S. SCHULTZ *is president of Industrial Relations Methods, Inc., New York, a professional consulting and research service that assists business and industry to design, install and simplify methods and procedures for management of people.*

For more than 25 years, Dr. Schultz has been a management and personnel consultant to business and industrial organizations. He earned his Ph. D. at the University of Pennsylvania, and for 15 years was adjunct professor of management engineering at New York University's graduate school of engineering.

Your author has specialized in research and professional services for the chemical process industries including appraisal and aptitude-test techniques for selection of employees and executive personnel.

He holds memberships in the American Psychological Assn., American Management Assn., and the Industrial Relations Research Assn.

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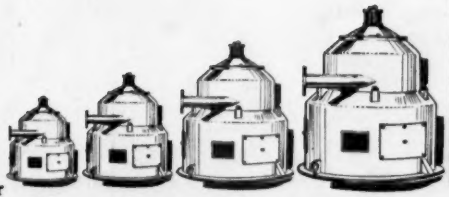

Super Conejector Models 210 310 410 510

with the SHARPLES SUPER CONEJECTOR

WHY is the Super Conejector superior to other types of centrifuges for certain types of solids dewatering? Why can many crystalline solids and fibrous pulps be dewatered at higher throughput rates, to desired dryness and particle size classification by the Sharples Super Conejector?

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Second, because specific process requirements can be met by varying screen size, rotational speed, etc.

Third, because only Sharples has four sizes of Super Conejector from which to select the one best suited for your particular requirements.

The Super Conejector fills an important spot in slurry processing and in many dewatering applications it offers unexcelled efficiency, capacity, and low cost. We'll gladly send you descriptive literature on the Super Conejector.

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Moisture: Key to Bromine Corrosion

Dry, bromine is harmless to many metals; but moisture turns it into a vigorous corrosive. For usual water contents, Monel, nickel, bronzes work fine.

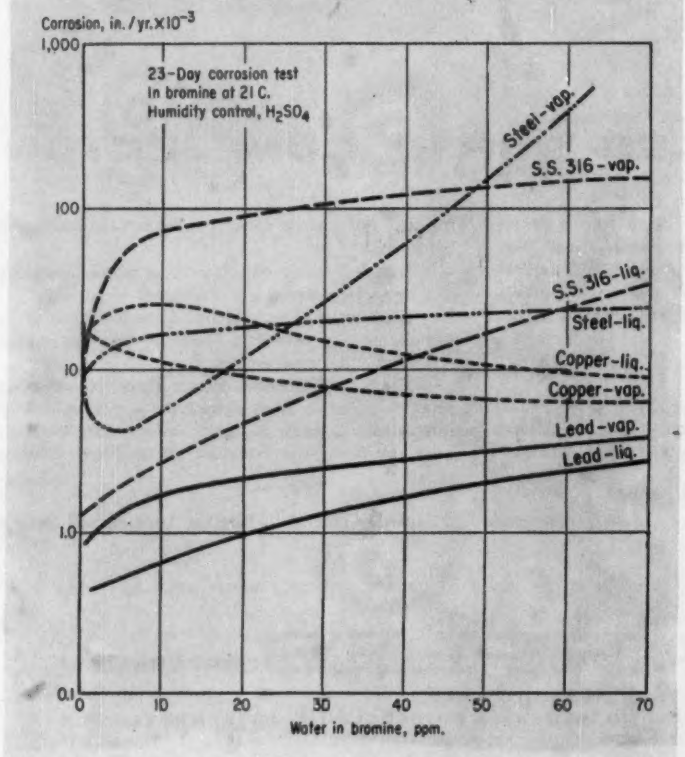
D. E. LAKE, A. A. GUNKLER, *Bromine Sect., Dow Chemical Co., Midland, Mich.*

When completely dry, bromine is not corrosive to many nonferrous metals, including nickel, copper and magnesium (it is highly reactive, wet or dry, with aluminum).

Commercial bromine is shipped with a water content below 20-30 ppm. but bromine has an affinity for moisture and may pickup additional water if improperly handled. For instance, at room temperature bromine could reach 70 ppm. of water if contacted with 20% relative humidity air. This could rise to 300 ppm. if bromine is exposed to air having 80% relative humidity.

We have run experiments to determine how critical moisture content is for a range of metals. Tests were run in the laboratory in chambers where humidity was controlled with baths of sulfuric acid. Exposure was on three samples: one totally immersed, one suspended through the bromine surface, the third merely exposed to bromine vapors.

These alloys corrode swiftly in bromine—Fig. 1



► **Metal to Use**—Metals considered generally satisfactory for liquid or vapor exposure include chemical lead, Ounce metal (85% Cu, 5% Zn, 5% Pb, 5% Sn), Muntz metal, Monel, nickel.

Corrosion rates look like this: in in./yr. × 10^{-4}

	Water in Bromine, Ppm.	
	7	57
Monel, liquid Br_2....	0.10	0.46
Monel, vapor	0.04	1.32
Nickel, liquid	0.07	0.20
Nickel, vapor	0.05	0.83
Al bronze, liquid.....	0.27	0.18
Al bronze, vapor.....	2.86	66.80
Muntz metal, liquid...	0.35	0.80
Muntz metal, vapor...	0.79	1.39
Chem. lead, liquid....	0.53	2.28
Chem. lead, vapor....	1.67	3.64
Ounce metal, liquid...	0.46	1.76
Ounce metal, vapor...	0.05	0.45

Except for Al bronze in the vapor, the metals listed are generally superior to lead. The curves (left) give data for metals with less corrosion resistance than lead and are unsatisfactory for industrial uses.

From our evaluation, the bronze group should find economical application in bromine service along with accepted nickel, Monel and lead. Both steel and stainless steel are unsatisfactory because of contamination and corrosion.

► **Coatings Form**—In most cases, visible coatings form on the metal surfaces and resistance to attack seems to be related to the insolubility of these coatings in bromine.

As would be expected with such film forming, initial corrosion may be considerably more severe than the long-period results may show. To check this, a 200-hr. exposure was conducted on nickel only. Fig. 2 shows a comparison of a 200-hr. exposure with a 23-day test. As the curves indicate, in the commercial range of 20-30 ppm. water, initial corrosion should not be an important factor.

► **Impure Bromine**—All tests were

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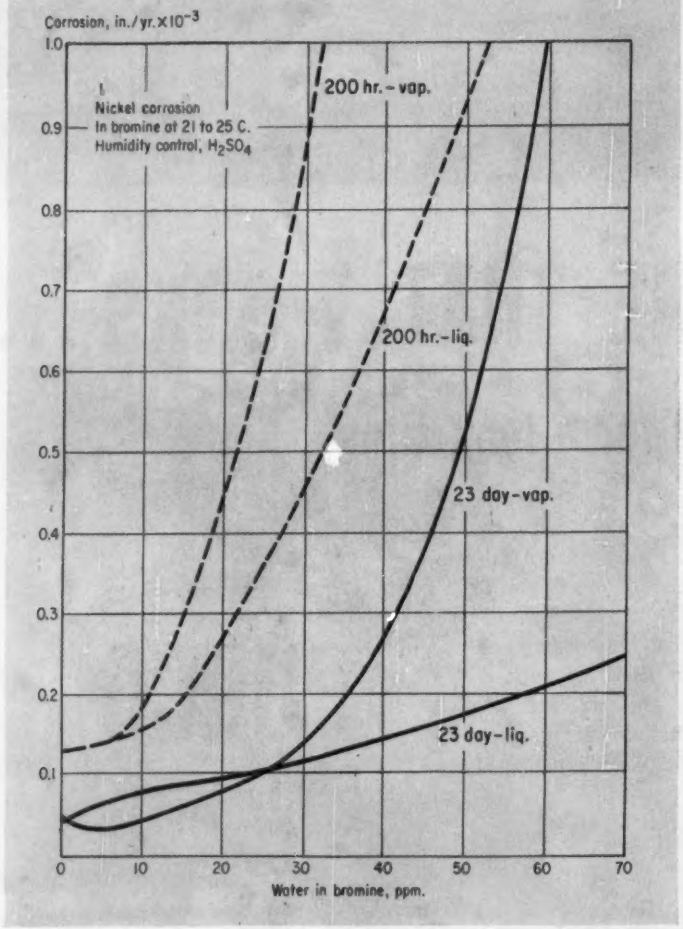
conducted on commercial bromine. Less pure bromine, containing organic impurities, has produced adverse corrosion on nickel and Monel, particularly above 50 ppm. water. This is caused by a slow substitution reaction of bromine for hydrogen in the dissolved hydrocarbon with the liberation of HBr. Dissolved water will then form a solution with the acid. This solution, saturated with bromine, may separate on the bromine surface, causing interface corrosion.

Most of the materials found to have low corrosion rates in the laboratory tests have been used successfully for many years in plant applications involving commercial bromine. For instance:

- Nickel-clad 2,400-gal. tank cars for liquid bromine in service for 10 yr.
- Chemical-lead-lined 2,400- and 4,000-gal. tank cars for liquid bromine in service for 9 yr.
- Monel 10-gal. drums in contact with liquid bromine, 9 yr.
- Nickel and Hastelloy C submerged bromine pumps, 10 yr.
- Z-nickel bearings for nickel pumps, 10 yr.
- Lead and nickel bromine vaporizers, 15 yr.
- Tungsten-carbide check valves in bromine diaphragm pumps, 8 yr.
- Nickel and bronze valves for liquid bromine, 13 yr.
- Tantalum for heating or cooling wet or dry bromine, 18 yr.
- Chemical-lead tanks for bromine storage, 27 yr.
- Chemical-lead bonded to nickel pipe lines, 10 yr.

Initial rates are not excessive on nickel—(Fig. 2)



► **Test Technique**—In the laboratory, water content of bromine was determined by infrared spectroscopy. This technique is accurate to 0.5 ppm. water and gives a direct quantitative determination of water from 0 to 100 ppm.

Previous to this test program, corrosion testing of metals in bromine has usually been limited to confined specimens in a sealed bromine sample. This technique has one big disadvantage: the bromine metal salts are frequently hydroscopic and can greatly reduce the water content of large volumes of bromine.

To overcome this problem, tests were conducted in chambers (desiccators) where humidity was controlled with sulfuric acid. Exposures were made on three samples, each exposed to bromine in separate, open containers (liquid, vapor, liquid-vapor).

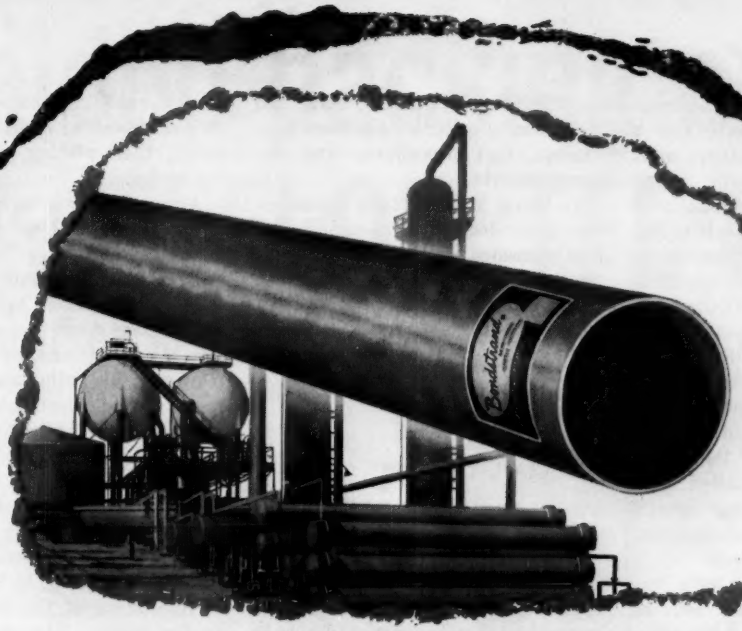
Testing was at room temperature (21-25C.) and weight loss was determined on totally exposed and vapor-exposed samples. No interface corrosion appears to take place on semi-immersed metal samples.

All of the tests point up a very important principle in industrial use of bromine. It is vital that moist atmospheres be kept away from bromine. At high summer temperatures, bromine could be saturated with 300-400 ppm. water if improperly stored and would be highly corrosive. A bromine-water, two-phase system will attack most metals except tantalum.

In most cases, the water content should be kept in the 20-30 ppm. range by a controlled dry atmosphere. A number of commercial metals and alloys can be used with safety if this precaution is taken.

New Electrode Spec Reduces Duplication

Anyone who has used federal or military specifications for covered welding electrodes has probably



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realized that there are a great number of such specifications and a large amount of duplication: most specification authors, in many cases, use different words, but cover the same ground. The result is loss of valuable engineering time; users examine an unfamiliar specification, required for a particular job, only to find that it duplicates something they've used before.

This is all changed. After three years of study, there is now a single specification for covered welding electrodes. Issued by the Navy Bureau of Ships, it is called MIL-E-22200 (Ships), Military Specification Electrodes, Welding, Covered; General Specification.

The result of a study by a special committee of the arc welding section of the National Electrical Manufacturers Assn. (NEMA), the specification includes general requirements, quality assurance provisions, test procedures and delivery instructions.

In using MIL-E-22200, a one- or two-page document is usually all that's needed to cover the unique properties of a particular electrode, instead of perhaps more than 20 or 30 pages.

Ni-Al Coating Resists Oxidation

The National Bureau of Standards, in a program sponsored by Wright Air Development Center, has developed a method for producing nickel-aluminum alloy coatings capable of protecting metals from oxidation at temperatures up to 1,850 F. The most durable coating was obtained by electroplating nickel over a base metal, then plating aluminum on the nickel.

Although cast nickel-aluminum alloys have good corrosion-resistance to atmospheric exposure and maintain their hardness at elevated temperatures, their brittleness prevents them from being fabricated into intricately shaped components. However, by using the alloy as a coating and electroplating it on more ductile metals, an effective corrosion-resistant material can be obtained.

In an attempt to find suitable plating conditions for producing a smooth, oxidation-resistant nickel-aluminum coating, D. E. Couch and J. H. Connor of the Bureau's electrodeposition laboratory studied aluminum plating baths prepared from either organic solvents or fused salts.

The most satisfactory procedure consisted in electrodepositing nickel from a Watts bath (mixed chloride-sulfate) and then electroplating aluminum on the nickel layer. The aluminum was deposited from a fused-salt solution containing a mixture of potassium chloride, sodium chloride, and cryolite (sodium aluminum fluoride) at 1,300 F. At this temperature, aluminum diffuses into the nickel layer, as it deposits, thus forming the alloy.

Steel specimens coated with the aluminum-nickel alloy were tested in salt-sprays, in outdoor exposure, and in air at elevated temperatures. In air at 1,000 and 1,850 F., the alloy coatings oxidized at one-tenth the rate of nickel coatings of comparable thickness. In salt-spray tests, panels plated from the cryolite bath proved to be the most durable. In fact, steel panels coated with 0.002-in. nickel and 0.0005-in. aluminum withstood 300 hr. in salt-spray tests before showing rust. Also, rapid thermal cycling of these panels between room temperature and 1,800 F. did not affect their corrosion resistance.

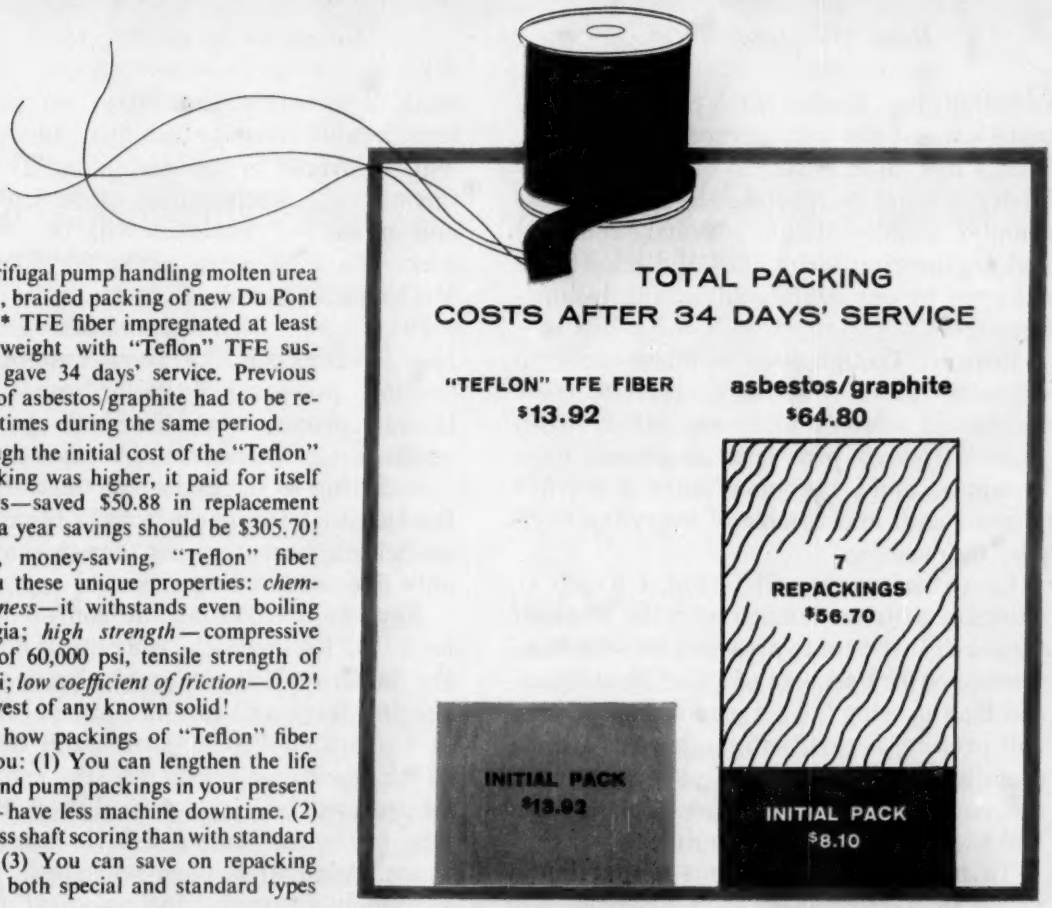
Coatings were more resistant when the aluminum thickness was less than 50% of the total coating thickness.

Confirm corrosion resistance of thick chromium plate

Both laboratory and outdoor exposure tests prove that thicker chromium plate on steel or zinc-die cast parts, with a suitable nickel undercoat, can remain free from corrosion for many years. This is a big improvement over standard chromium coatings used for many years in the automobile industry, according to Edgar Seyb, research supervisor at Metal & Thermit's electrochemical laboratory. Outdoor tests were run at Kure Beach, N. C.

Braided packing of new TEFLON® TFE FIBER

pays for itself in 8 days, saves $50.88 replacements costs



In a centrifugal pump handling molten urea at 130°C., braided packing of new Du Pont "Teflon"* TFE fiber impregnated at least 35% by weight with "Teflon" TFE suspensoid, gave 34 days' service. Previous packing of asbestos/graphite had to be replaced 7 times during the same period.

Although the initial cost of the "Teflon" fiber packing was higher, it paid for itself in 8 days—saved $50.88 in replacement costs; in a year savings should be $305.70!

Tough, money-saving, "Teflon" fiber gives you these unique properties: *chemical inertness*—it withstands even boiling aqua regia; *high strength*—compressive strength of 60,000 psi, tensile strength of 50,000 psi; *low coefficient of friction*—0.02!—the lowest of any known solid!

Here's how packings of "Teflon" fiber benefit you: (1) You can lengthen the life of valve and pump packings in your present process—have less machine downtime. (2) There's less shaft scoring than with standard packing. (3) You can save on repacking costs—in both special and standard types of service.

*"Teflon" is Du Pont's registered trademark for its TFE-fluorocarbon fiber.

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...THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.)
Textile Fibers Department, 31K1 Centre Road Building, Wilmington 98, Delaware

Please send me my free sample of braided fiber packing of Du Pont "Teflon" and new folder. I am interested in using this new packing material for_____

Name_____ Position_____

Firm_____

Address_____

City_____ State_____

Announcing . . .

A TECHNICAL CONFERENCE ON

Under the joint sponsorship of

MIDWEST RESEARCH INSTITUTE and Chemical Engineering

Hotel Muehlebach, Kansas City, Mo. *November 29 and 30, 1960*

Challenging, loaded with potential and, more often than not, darned troublesome. That's how most chemical engineers in industry are apt to describe the host of new, complex mathematical, physical, chemical and engineering techniques and knowledge spawned by our swiftly advancing technology.

Reason: Though sure to make chemical engineers more effective operatives, these techniques weren't in the curricula when most of today's practicing engineers were in school. Thus, they now must be learned in the rough and tumble of everyday engineering practice.

Recognizing this situation, CHEMICAL ENGINEERING has teamed with the Midwest Research Institute to present a two-day conference on key aspects of "The New Chemical Engineering." This pioneering meeting will present to practicing engineers ten especially prepared technical papers covering the new chemistry, the new mathematics and the new tools of the engineer.

To make all four sessions of maximum value to participants, each attendee will receive a complete set of preprints of these papers and ample time for questions and discussion has been allowed. No simultaneous sessions, which compete for attendees' interest and attention, will be held.

One paper on chemistry and one on mathematics will survey and review aspects of each discipline that are, or soon will be, important to the chemical engineer. Other papers in the initial-day meetings emphasize significant specifics in both chemistry and math. Solid-state chemistry, an area of considerable recent technical innovation, will be covered in the session on "The New Chemistry." Mathematics of control loops and numerical analysis will be featured when the conference explores "The New Mathematics" in depth.

In the two final-day sessions on "The New Tools of the Engineer," systems engineering, process kinetics, information retrieval, process statistics and operations research will be handled by experts.

Attesting to the caliber of the authors is the fact that two of them have been named as Schoch Lecturers, an honor shared by only five outstanding chemical engineers.

Keynote speaker at the conference will be S. D. Kirkpatrick, consulting editor of the McGraw-Hill series of chemical engineering texts and former editorial director of CHEMICAL ENGINEERING and *Chemical Week*. Featured speaker at the conference banquet will be Vice-Admiral W. F. Raborn, who heads the Navy's Polaris missile program. Admiral Raborn will speak on this extremely successful technological achievement, illustrated with a sound movie and slides.

Fee for this important and timely conference of $50 ($45 for those who preregister by November 21) covers attendance at the four technical sessions, two lunches, a cocktail party, the banquet and a tour of Midwest Research Institute facilities. Each registrant will also be supplied with a set of preprints of the ten technical papers in a souvenir briefcase.

THE NEW CHEMICAL ENGINEERING

The Program For The Conference

(Registration desk open from 6 PM, November 28 to 4 PM, November 30)

Tuesday, November 29

9:30 AM, First Session

Welcome, M. H. Thornton, Midwest Research Institute

Keynote Speech, S. D. Kirkpatrick, McGraw-Hill Book Co.

The New Chemistry

- Survey of the New Chemistry, Norman Hackerman, Univ. of Texas
- Solid State Chemistry, Rowland Johnson, Texas Instruments Inc.

12:15 PM, Lunch

1:45 PM, Second Session

The New Mathematics

- New Uses for Mathematics, J. S. Dahler, Univ. of Minnesota
- Mathematics of Control Loops, T. J. Williams, Monsanto Chemical Co.
- Numerical Analysis, Yudell Luke, Midwest Research Institute

6:15 PM, Reception and Cocktail Party

7:00 PM, Banquet

C. N. Kimball, president, MRI, presiding. Vice-Admiral W. F. Raborn, U.S.N., speaker.

Wednesday, November 30

9:00 AM, Third Session

New Tools of the Engineer – I

- Systems Engineering, T. C. Wherry, Phillips Petroleum Co.
- Process Kinetics, Henry Eyring, Univ. of Utah
- Information Retrieval, J. W. Perry, Univ. of Arizona

12:00, Lunch

1:30 PM, Fourth Session

New Tools of the Engineer – II

- Process Statistics, T. L. Koehler, American Cyanamid Co.
- Operations Research, J. C. Hetrick, Arthur D. Little, Inc.

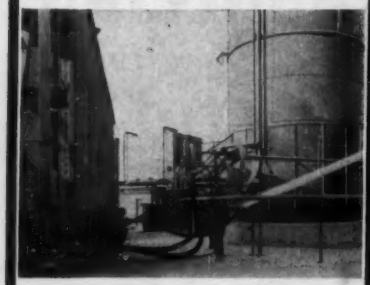
4:00 PM, Guided Tour of Midwest Research Institute (Buses leave hotel).

5:00 PM, Tour Ends, guests returned to hotel.

Conference fee is $50. However, your advance registration, postmarked no later than November 21, entitles you to a 10% reduction in exchange for your help in anticipating accommodations required. For registration information and hotel reservations write to B. C. Shaw, Midwest Research Institute, 425 Volker Blvd., Kansas City 10, Mo.

PROBLEM:

to cut costs and gain floor space in flour handling operations



SOLUTION:

SPROUT-WALDRON PNEUMATIC SYSTEM

In addition to the standard savings of 12¢ per bag which automatically applies when you shift from bag to bulk flour, Chef Boy-Ar-Dee, Milton, Penn., gained these advantages with the Sprout-Waldron pneumatic system:

1. Faster handling
2. Lower operating costs
3. Simplified maintenance
4. 10,000 square feet of floor area
5. Improved housekeeping

The system picks up from rail cars and delivers the flour to storage at rates of 20 tons per hour. It then transfers it 600-700 ft. to plant bins at rates of 6000 pounds per hour. Heat exchangers incorporated in the system keep the flour at proper blending temperature at all times.

For the full story of savings at Chef Boy-Ar-Dee request Bulletin 1-54.

PROBLEM:

to fiberize asbestos faster and more economically

SOLUTION:

SPROUT-WALDRON ATTRITION MILL

Equipment for fiberizing and blending milled asbestos at. Garlock Packing Company, Palmyra, N. Y. included a roll crusher, a vertical opener, and a willow used in conjunction with a ceiling condenser. These were replaced with a Sprout-Waldron 36″ single runner attrition mill.

The following advantages have been noted:

1. Fiberizing and blending have been improved
2. Production rate has been increased
3. Waste has been reduced
4. Maintenance costs have been cut
5. Operating cost is down

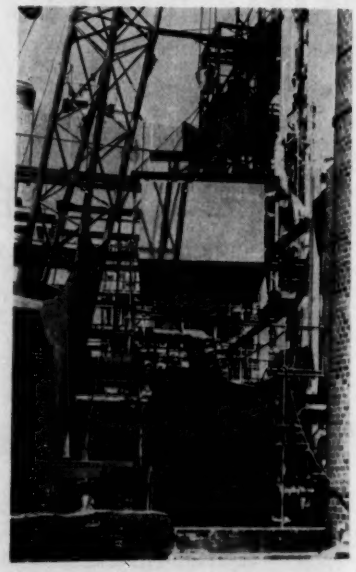
In addition to these advantages, the attrition mill results in a more compact, space saving installation.

For details on the Sprout-Waldron line of single runner attrition mills, ask for Bulletin 143.

SPROUT, WALDRON & CO., INC.
MUNCY, PENNSYLVANIA
SINCE 1866
Size Reduction • Size Classification • Mixing & Blending
Bulk Materials Handling • Pelleting & Densifying

COP/106

CPI NEWS BRIEFS . . .
(Continued from page 58)



Texaco Inc. recently installed an air preheater, having 5,800 sq. ft. of heating surface, on a crude still at the firm's Lockport, Ill., refinery. The new unit, shown being positioned above, receives furnace exhaust gases at 1,000 F. and heats incoming air from 50 to 754 F. It was manufactured by Air Preheater Corp., New York.

Shell Chemical Co. plans to build a multimillion-dollar polyisoprene plant near Marietta, Ohio. Design capacity will be 80 million lb./yr., bringing the company's total polyisoprene capacity to 120 million lb./yr. (Shell is currently expanding its polyisoprene level at Torrance, Calif., to 40 million lb./yr.) Petroleum-derived feedstocks for the Marietta installation will come from Shell Oil's refinery at Wood River, Ill. Due to be on stream late next year, the new facility will be constructed by C. F. Braun Co., Alhambra, Calif., and Ralph M. Parsons Co., Los Angeles.

Halifax Paper Co., Roanoke Rapids, N. C., announces a $1.75-million program to expand pulp production. Present capacity is 740 tons/day; expanded capacity will be 800 tons/day, and the new facilities will also permit Halifax to

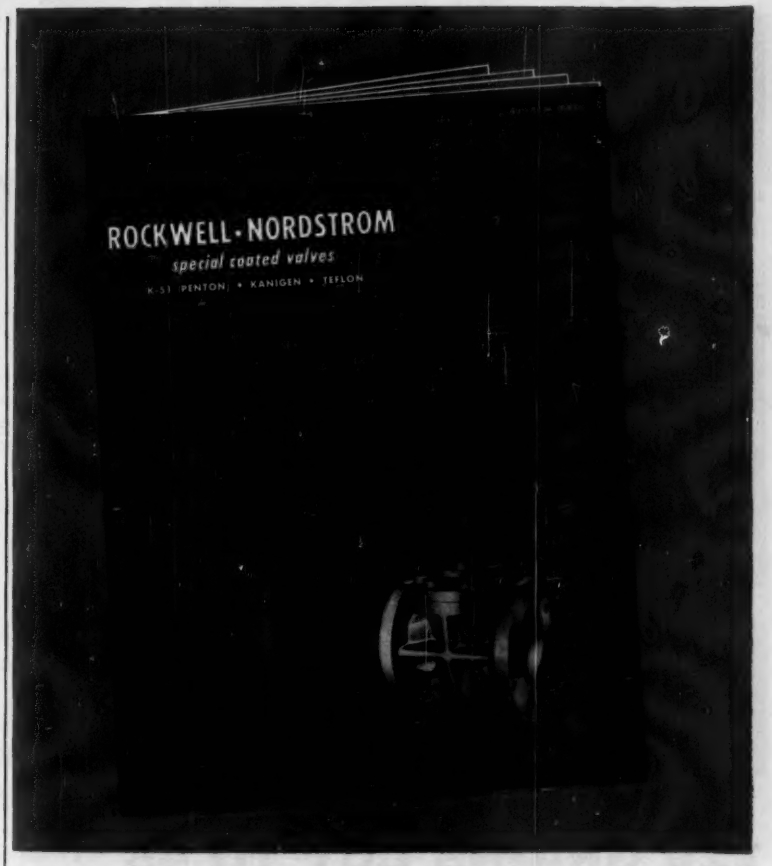
pulp hardwood and pine at the same time. Plant additions will include two digesters, a blow tank, a two-stage pulp washer, a lime kiln and other equipment.

Mid-America Pipeline Co., Tulsa, Okla., plans to construct a $21-million condensate pipeline next year between Superior, Wis., and Chicago. The 10-in., 405-mi. line will connect with the existing Inter-Provincial Pipeline System in Alberta, Canada, and also with gathering systems now being developed, to carry natural gas condensates into the Chicago area. Initial daily capacity will be 26,000 bbl.

Texas Eastern Transmission Corp., Houston, is also expanding its pipeline system. Company plans to increase its daily delivery capacity for current customers by about 150 million cu. ft. Half the new capacity is to be added in 1961 and the rest in 1962, for a total cost of about $70 million. Gas supply to make up the new capacity will come mainly from an undisclosed pipeline supplier in northern Louisiana.

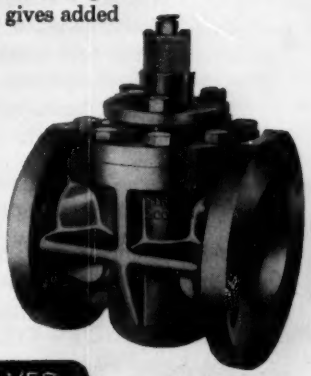
Raybestos-Manhattan, Inc., Manheim, Pa., recently held open house for its new Pacific Coast Div. plant at Fullerton, Calif. Facility, shown above, contains 25,000 sq. ft. of manufacturing space. It replaces a former plant operated at Paramount, Calif., and gives the firm enlarged facilities for turning out plastics products made from Teflon and Kel-F. (Teflon is a line of Du Pont fluorinated ethylenes; Kel-F is a line of fluorocarbons produced by Minnesota Mining & Mfg. Co.)

The Philip Carey Mfg. Co. is installing facilities at its Lockland,

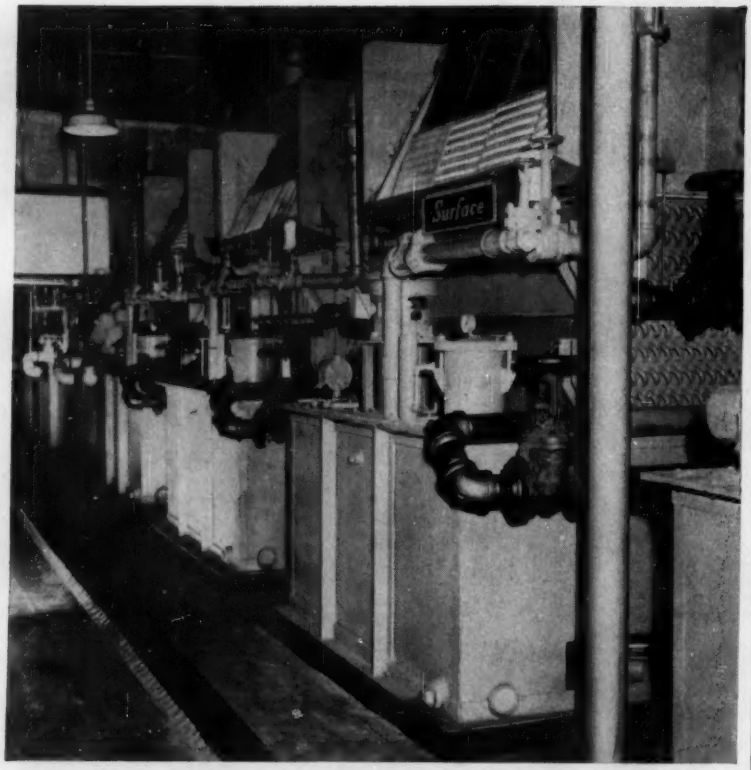


Get this NEW BOOKLET on ROCKWELL—NORDSTROM Valves with Teflon Coated Plugs

Rockwell-Nordstrom standard pattern valves with Teflon coated plugs are now available for use where infrequent or inadequate plug valve lubrication might be expected. The coating of tough Teflon gives added lubricity to the plug for longer valve life and easier operation. For complete information on Teflon, as well as corrosion resisting K-51 (Penton) and Kanigen coatings, write for the new booklet on special coated valves to: Rockwell Manufacturing Co., Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Limited.



ROCKWELL-Nordstrom VALVES
another fine product by
ROCKWELL



120 GRAINS CUT TO 45 IN 200,000 cfm OF AIR WITH 85° TOWER WATER

Without Kathabar, this job would have taken 1800 tons of refrigeration, at about 35F and reheating air from about 45F to 98F! With Kathabar the job took 63 hp instead of 2000. Ask the men who have seen Kathabar Type C units serve for years with practically no maintenance. Write for specific information.

Surface

SURFACE COMBUSTION

Division of Midland-Ross Corporation

2380 Dorr St., Toledo 1, Ohio

Send facts on Kathabar systems for the following application:

name and title.....

company.....

street.....

city.....*zone*.....*state*.....

Ohio, plant to double manufacturing capacity for the firm's industrial heat-insulation material, known as Careytemp. Expanded plant will be in operation early next year.

Shell Oil Co. has placed a new hydrotreating unit on stream at the firm's refinery in Houston. Facility has a capacity of 6,500 bbl./day, removes sulfur and other impurities from low- and high-viscosity-index lube stocks and from transformer oils.

Sunray Mid-Continent Oil Co.'s subsidiary, DX Sunray, has placed a $7-million wax plant on stream at its Tulsa, Okla., refinery. Having an annual capacity of over 100 million lb. paraffin and microcrystalline grades, the facility is said to make Sunray Mid-Continent the world's third-largest producer of petroleum waxes.

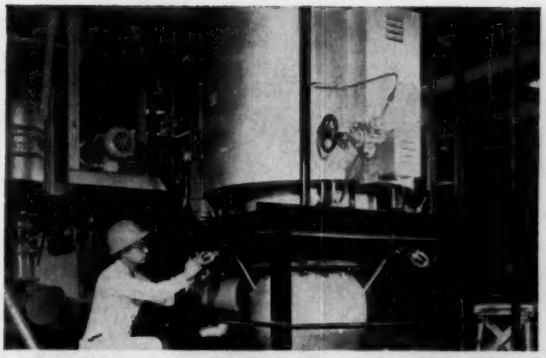
Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., is spending $8 million to expand its production of enamel paper. Most of the money will be spent at the firm's Wisconsin River Div. plant at Whiting, Wis., where a new 25,000-ton paper machine is to be installed. The new machine will give Consolidated a total capacity of 300,000 tons/yr. enamel paper.

Offices

Fluorocarbon Co., a Southern California producer of fluorocarbon plastics, has moved its entire Fullerton plant to new, larger quarters at Anaheim. The new facility houses the firm's administrative, sales and engineering offices as well as the production department.

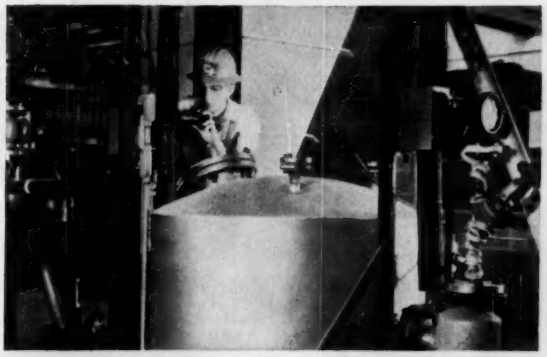
W. F. Fancourt Co., a chemical manufacturing firm, has bought a 10-acre tract at Greensboro, N. C., and will move its headquarters there. Now located in Philadelphia, the company will construct a three-story building to house main offices, laboratories and manufacturing facilities on the new

Step 1. Counter-flowing anhydrous HF reacts with crude UO_2 in two series-connected Inconel fluid-bed reactors to form UF_4. Inconel* nickel-chromium alloy resists HF and volatile fluorides at 900°-1100°F, also promotes fast heat transfer.



Step 2. UF_4 is treated with F_2 to form UF_6. The reaction at 800-1000°F is fast and exothermic. Monel* nickel-copper alloy fins and wall surfaces help keep temperatures down. Its strength and resistance to F_2 and UF_6 are high.

Step 3. Crude UF_6 trapped cold, is vaporized and fed to fractional distillation unit (low boiler shown) where it is purified, condensed and packed in ten ton product cylinders. Extensive pilot plant tests led to the specification of Monel alloy.



Step 4. Almost 100% recovery of Uranium is obtained by recovering and processing residue UF_4 in the conventional Monel refluorination system shown here in part. Both Monel and Inconel alloys are readily welded and fabricated.

In production of pure uranium hexafluoride:

Nickel alloys resist attack by HF and F_2 at 1000° F and up

Uranium ore concentrates from many of the domestic mills in the Colorado plateau area are converted to uranium hexafluoride in this plant. It is owned and operated by Allied Chemical Corporation's General Chemical Division. The new process employed was specially developed by Allied engineers.

Allied processes ore concentrates directly to UF_6 by successive reduction, hydrofluorination, and fluorination. Inconel nickel-chromium alloy is used for the hydrofluorinators because of its superior resistance to HF, mechanical properties at 900-1100°F, and heat transfer. Equipment handling fluorine in the fluorination of UF_4 is made of Monel nickel-copper alloy. It has excellent resistance to fluorine at 800-1000°F, good heat transfer, and satisfactory strength.

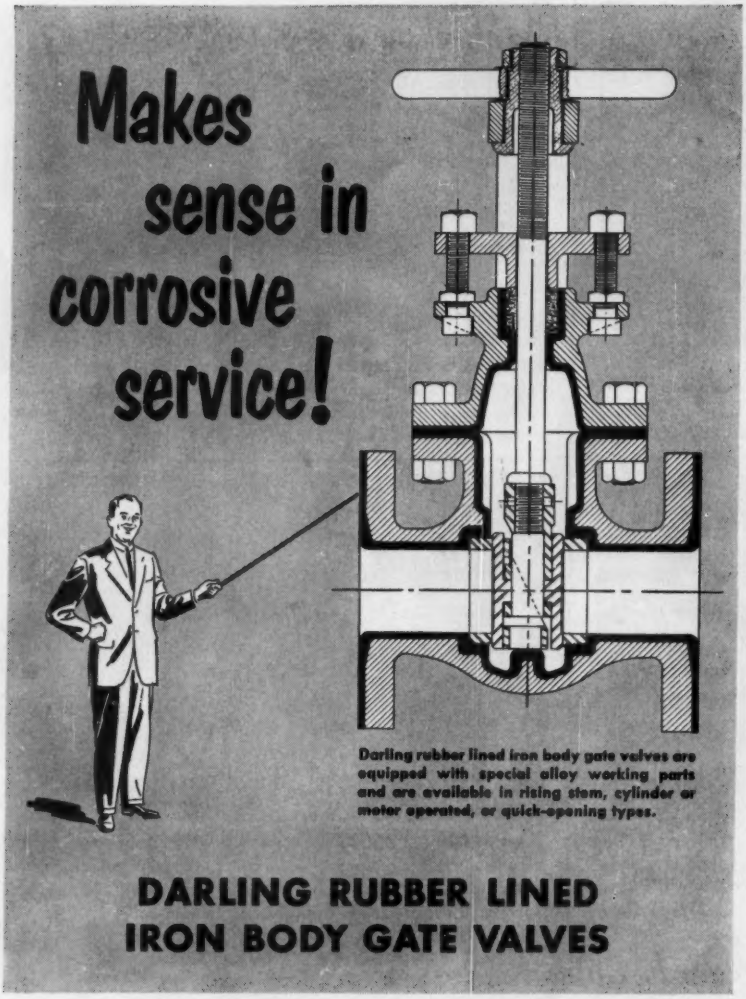
This UF_6 plant at Metropolis, Illinois can annually handle uranium ore concentrates containing up to 5000 tons of U_3O_8. Its yield, when converted to uranium fuel, is sufficient to produce almost twice as much heat potential as in all coal burned in U.S. power plants during 1958.

*Inco trademark

Documentation for the use of Monel and Inconel alloys in handling fluorine and its compounds can be obtained easily. Write for our 24-page booklet, "Handling Fluorine and Fluorine Compounds."

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17, West Virginia

INCO TRADE MARK **ALLOY PRODUCTS**

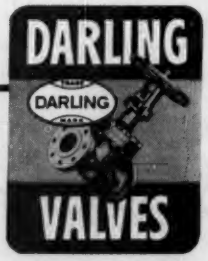

Makes sense in corrosive service!
Darling rubber lined iron body gate valves are equipped with special alloy working parts and are available in rising stem, cylinder or motor operated, or quick-opening types.
DARLING RUBBER LINED IRON BODY GATE VALVES

Problem: How to get away from costly, special alloy gate valves in handling corrosive fluids and still have long, trouble-free valve life.

Answer: For pressures up to 150 pounds and temperatures to 180° use Darling iron body gate valves with the permanently bonded hard rubber lining. They're giving outstanding service in job after job. Moreover, they have the Darling *fully revolving double disc parallel seat feature* that multiplies disc and seat life and assures tight closure longer . . . much longer!

Write for complete information on these exceptional rubber lined valves . . . or for data on other Darling gate valves including the range of alloys, types and constructions for ordinary or special services.

DARLING VALVE & MANUFACTURING CO.
Williamsport 3, Pa.
Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.



site, and hopes to complete the changeover by next summer.

Midwest Piping Co., St. Louis, has opened a sales office in Pittsburgh. It will be headquarters for the sales territory that includes western Pennsylvania, West Virginia and southeastern Ohio.

Parke, Davis & Co. is erecting a distribution building at Memphis, Tenn., which will handle the firm's entire line of pharmaceuticals and other products for sales in northern Alabama and Mississippi, as well as most of Arkansas and Tennessee. The facility is due to be completed early next year.

Parke, Davis also completed a new distribution center at Dallas recently. It serves northern Texas, southern Oklahoma and eastern New Mexico.

Companies

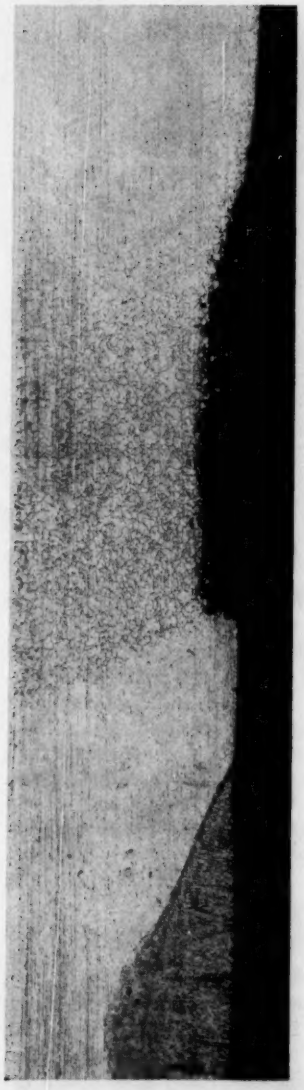
Wallace & Tiernan, Inc., Belleville, N. J., and **R. J. Strasenburgh Co.**, Rochester, N. Y., have announced a merger agreement. Boards of directors of both companies have approved the move, which is subject to ratification by stockholders. Plans call for Strasenburgh to retain its own name while operating as a division of Wallace & Tiernan. Both firms are in the pharmaceutical field; Wallace & Tiernan also makes chemicals, instruments and mechanical equipment.

Crucible Steel Co. of America, Pittsburgh, has purchased (through its wholly owned subsidiary, World Crucible Ltd.) 75% ownership of the Fonderie Acciaierie Milanesi Vanzetti, Sp. A. of Milan, Italy, a producer of special steels. Move enables Crucible to enter and participate in the European Common Market.

Aerojet-General Corp., subsidiary of General Tire & Rubber Co., has bought a controlling interest in Space Electronics Corp, Glendale, Calif. Space Electronics conducts

Eliminate This Corrosion Problem at Least Cost With Armco ELC Stainless Steels

New steels are born at Armco



Intergranular corrosion that results from harmful carbide precipitation during welding of stainless can be controlled by several methods. But the most practical and the lowest in cost is the use of Armco 304L, 316L or 317L Stainless Steel.

Their extra-low carbon content, 0.03% maximum, eliminates corrosion-inducing carbide precipitation that results when welded equipment is made of regular stainless grades. Provided operating temperatures are below 800 F, there is no need to use expensive stabilized grades or go to the trouble and expense of annealing welded structures.

In addition, the Armco ELC grades make it possible to assemble or repair equipment in the field by welding. You not only can reduce first costs but keep maintenance expense at a minimum.

For maximum economy, use Armco Extra-Low Carbon Stainless Steels for welded equipment that operates at 800 F and below. Let us send you more information on these Armco Stainless Steels and their cost-reducing use in chemical plants. Just write us or contact your Distributor of Armco Stainless Steel.
Armco Steel Corporation, 2970 Curtis Street, Middletown, Ohio.

Photomicrographic cross-section of a weld in regular Type 302 stainless steel. Weld was exposed to a severely corrosive medium to show weld area subject to carbide precipitation and subsequent intergranular corrosion.

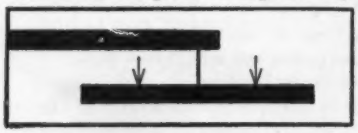
ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

How did this team solve an age-old weighing problem?

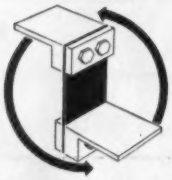
Since 5,000 B.C. men have been trying to devise a pivot balance that would be highly sensistive yet remain accurate. The breakthrough came in 1956 when the United States issued a patent for a "Thayer Flexure Plate" Leverage System. A team of engineers and businessmen, aware of industrys great cumulative loss of materials in weighing operations, had invented a revolutionary new scale.

Knife-edged pivots that progressively wear and change were replaced by Thayer Flexure Plates that move only .001", yet accurately reflect the minutest changes in weight. This *firmly joined* lever withstands shocks and vibrations indefinitely. Dirt and dust are no longer a problem. Thayer guarantees this leverage system accurate for the life of the scale.



How Can It Save You Money Year After Year?

Working in conjunction with straight electrical controls, it forms the most reliable, low maintenance system ever devised to control processing or materials handling *by weight*. Literature on its application to filling, batching and checkweighing operations is available on request.



THAYER SCALE

AUTOWEIGHTION SYSTEMS FOR FILLING BATCHING AND CHECKWEIGHING

THAYER SCALE CORP. THAYER PARK PEMBROKE, MASS

A Subsidiary of SUNDSTRAND CORPORATION

mainly missile and space research for the government. Purchase price was said to be $1.08 million in cash.

National Gypsum Co., Buffalo, has acquired Allentown Portland Cement Co., Allentown, Pa., through an agreement involving National stock valued at over $31 million. Move adds three plants to National's network of facilities, boosts the firm's cement capacity by about 38% to 16.5 million bbl./yr.

TRW Computers Co. has been announced as the new name for The Thompson - Ramo - Wooldridge Products Co. The firm will continue to function as computer division of Thompson Ramo Wooldridge Inc., and headquarters will remain in Beverly Hills, Calif.

Baldwin-Montrose Chemical Co. is to be the name of a new corporation that will be formed if current negotiations are completed for a three-way merger of Montrose Chemical Co., Newark, N. J., Baldwin Rubber Co., Pontiac, Mich., and Centlivre Brewing Corp., Ft. Wayne, Ind.

Northern Propane Gas Co. is a new, wholly owned subsidiary of Northern Natural Gas Co., Omaha, Nebr. It will develop retail propane markets in the Northern Plains area. As a first step, the new subsidiary has purchased Blaugas Co., Omaha, and Cygas Corp., which has facilities in Neligh, Nebr., and Sargent Bluffs, Iowa.

International

Canada: Canadian Forest Products Ltd. will build a $50-million pulp and wood products operation in northern Alberta, supplementing facilities that the firm now operates in British Columbia.

France: Esso Standard S.A.F. plans construction of a hydrogenation unit and an aromatics plant for its refinery at Port Jerome,

. . . WITH EVERY SWENSON INSTALLATION!

You buy more than precisely fabricated metal whenever you invest in a Swenson Evaporator, Crystallizer, Dryer, Filter or Pulp Washer. You also purchase the close, personal interest of your Swenson engineer.

Swenson engineering integrity demands meticulous preliminary planning, insists on pre-installation testing and oversees every phase of installation. Your Swenson engineer makes post-installation checks, too, assuring the continuous control of processing and production that has made "Swenson" synonymous with profitable, trouble-free operation.

For experienced consultation—and accurate cost studies—you'll find a Swenson engineer at the other end of your phone.

SOMETHING YOU CAN USE!

Ask for Bulletin SW 205—*FORCED CIRCULATION EVAPORATORS*—eight-page treatise on salting and non-salting types, single and multiple effects. *Swenson Evaporator Company, 15669 Lathrop Ave., Harvey, Illinois. In Canada: Whiting Corporation (Canada) Ltd., 350 Alexander Street, Welland, Ontario, Canada.*

PROVED ENGINEERING FOR THE PROCESS INDUSTRIES SINCE 1889

SWENSON

A Division of WHITING Corporation

WHITING-MANUFACTURERS OF CRANES; TRAMBEAM® HANDLING SYSTEMS; PRESSUREGRIP; TRACKMOBILES,® FOUNDRY, AND RAILROAD EQUIPMENT

STOP COSTLY CORROSION DAMAGE...

CEILCOTE E-900
. . . dependable coating for severe corrosion service!
COROBOND
. . . acid-proof cement used with Ceilcote Brick!
CEILCRETE
. . . combined with glass cloth for extreme chemical resistance!
COROCRETE
. . . monolithic flooring four times stronger than concrete!

10021-CC

WITH CEILCOTE

ENGINEERED FLOORS

Ceilcote *Engineered Floors* are the answer to costly floor maintenance problems caused by acid and alkali attack. And Ceilcote floors are engineered to withstand impact, thermal shock, abrasion and expansion without cracking or spalling! The installation shown above exemplifies Ceilcote's comprehensive approach to individual flooring problems . . . demonstrates how Ceilcote materials are carefully integrated to completely protect all types of surfaces. Working under contract, competent Ceilcote engineers analyze your operating conditions . . . formulate materials . . . direct surface preparation and installation by Ceilcote construction crews. Some installations can be installed under Ceilcote supervision or by plant personnel. *This complete flooring package with guaranteed performance is available only from Ceilcote!*

Write today or call your nearest Ceilcote Representative . . .

CEILCOTE

THE CEILCOTE COMPANY, INC.
4836 Ridge Road • Cleveland 9, Ohio

ALABAMA: BIRMINGHAM LY. 2-7201. CALIFORNIA: OAKLAND TE. 2-0103, SANTA ANA P.O. BOX 625. COLORADO: DENVER GL. 5-3651. WASHINGTON, D.C. OL. 6-4321. FLORIDA: CORAL GABLES MO. 5-1965. ILLINOIS: CHICAGO AN. 3-1881. INDIANA: EVANSVILLE HA. 3-3597. MASSACHUSETTS: SPRINGFIELD RE. 6-5203. MICHIGAN: DETROIT UN. 4-6871. MISSOURI: KANSAS CITY MI. 9-1312. NEW JERSEY: PRINCETON WA. 1-6969. NEW YORK: NEW YORK CO. 7-0276, ROCHESTER GR. 3-5918. N. CAROLINA: CHARLOTTE JA. 3-8784. OHIO: CINCINNATI EL. 1-5765, CLEVELAND ER. 1-4558. PENNSYLVANIA: PHILADELPHIA KI. 5-0720, PITTSBURGH AT. 1-8500. TENNESSEE: KNOXVILLE 2-5770. TEXAS: HOUSTON JA. 2-1606. WASHINGTON: SEATTLE SU. 3-9200. CANADA: OTTAWA CE. 3-7785.

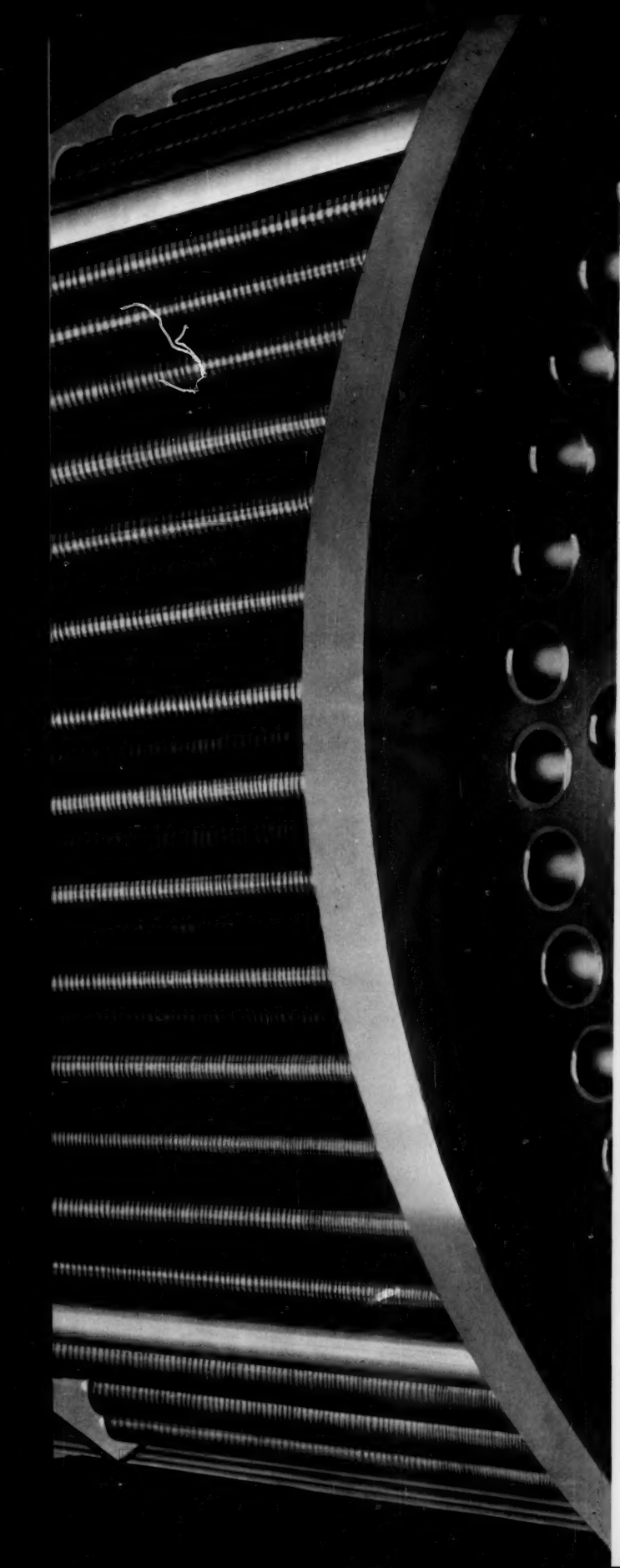
near Le Havre. Total cost of the two facilities will be close to $9.5 million.

The hydrogenation unit, which will provide catalytic treatment of distillates for lubricating oils, will have a capacity of 770 U.S. tons/day. It is to go on stream in the second half of 1961. The aromatics plant will produce ortho- and para-xylene as well as a variety of aromatic solvents. Scheduled to start up in the first half of 1962, its total capacity will be 49,500 tons/yr.

Canada: British Titan Products (Canada) Ltd. has broken ground at Tracy, Que., for construction of a $16-million plant. The company, a subsidiary of British Titan Products Ltd., produces titanium oxide. Its new facility is to be completed within two years.

Spain: Monsanto Iberica S.A. of Spain is a new company formed jointly by Aiscondel S.A. of Barcelona and Monsanto Overseas S.A. Latter firm is a wholly owned subsidiary of Monsanto Chemical Co., St. Louis. The new Spanish venture has already acquired an Aiscondel subsidiary plant near Barcelona that produces plasticizers, stabilizers and lauroyl peroxide. Next move will be construction of a plant at Monzon, which will make calcium carbide, acetylene and acetylene derivatives. It is scheduled to go on stream in the second half of 1961.

Canada: New Mylamaque Explorations, Ltd., a firm that owns iron ore properties north of Kingston, Ont., has contracted with Koppers of Canada, Ltd., subsidiary of Koppers Co., Inc., Pittsburgh, and Strategic Materials Corp. for construction of a smelting plant near Kingston. Expected to begin operating in the first half of 1962, it will produce pig iron by the Strategic-Udy direct reduction process. Over-all project will also include a concentrating plant and will have a total cost of about $14 million. The contract calls for technical and operational management of the smelter by Koppers Co., Inc.



You can afford to do it better for less

IT'S THAT SIMPLE!

By having your shell and tube heat exchangers and condensers designed around Wolverine Trufin® Type S/T, you actually can, in many cases, afford to replace admiralty tubing with higher grade alloys such as cupro-nickel.

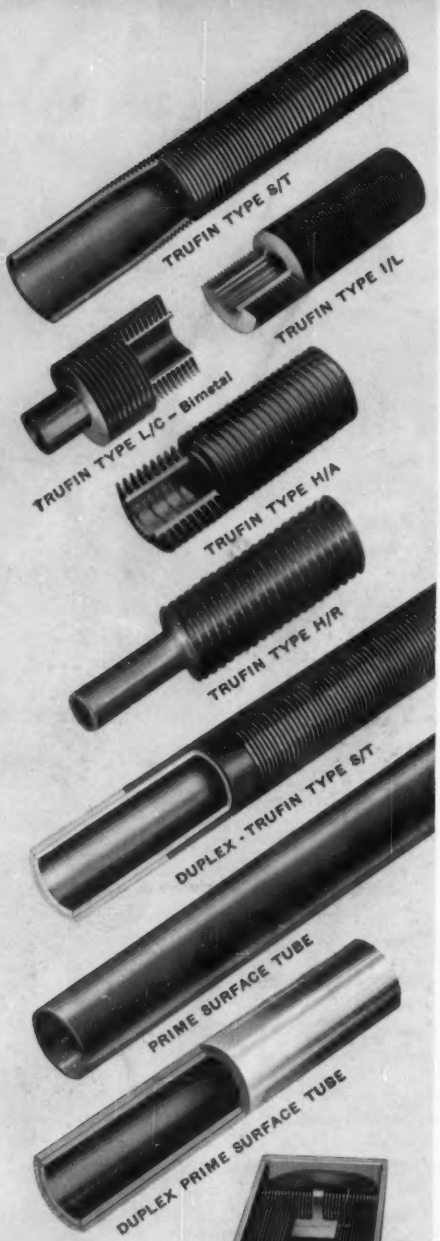
The result is a unit with greater resistance to corrosion and erosion—one that will stay on stream longer with a minimum of maintenance.

The answer, of course, comes from the greatly increased surface area gained by Trufin Type S/T because of its integral fins.

These fins are actually squeezed from the tube wall and give Trufin Type S/T as much as 2½ times more surface area than a comparable piece of plain tube. As a result, you handle more BTU's per foot of tube, thus use fewer tubes, smaller shells, headers and baffles and, in the case of overhead units, less structural support.

For complete information about how Wolverine Trufin Type S/T can help you do a better job for less, just write for your copy of the Trufin Catalog. Or better still—

Ask your Wolverine Salesman.



U-BEND PALLETS

Only Wolverine Tube can offer all these extra condenser tube values

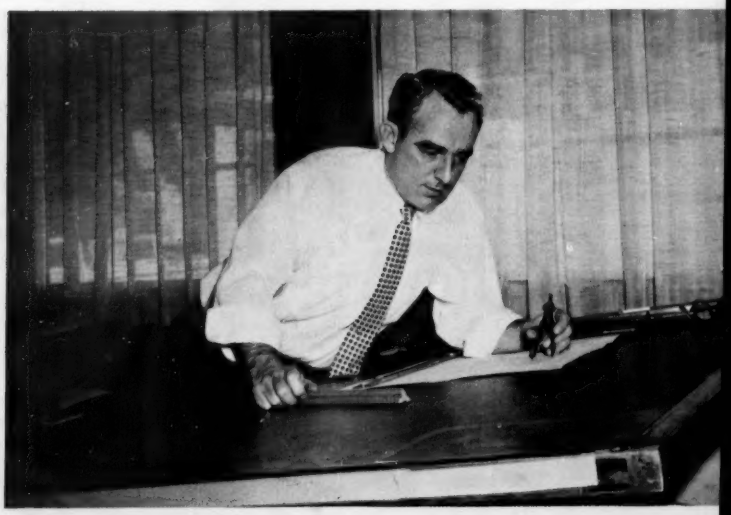
ONLY WOLVERINE?

Yes, that's right . . . because only Wolverine Tube, in the entire tubing industry, has had years and years of experience in manufacturing integrally finned condenser tube.

Wolverine's experience, for example, goes back to 1928 when it first developed Wolverine Trufin. Since then, through its own engineering research, and in conjunction with the University of Michigan, Wolverine Tube has compiled almost all the existing technical data concerning the applications and advantages of integrally finned tube.

This too, is why only Wolverine Tube is able to offer tubing users the services of its staff of Heat Transfer Specialists—highly trained men who know exactly how integrally finned tubing can help you.

Yes, only Wolverine—because of its research and years of experience—can give you truly competent finned tube guidance. For the complete story write for your copy of the Trufin Catalog.

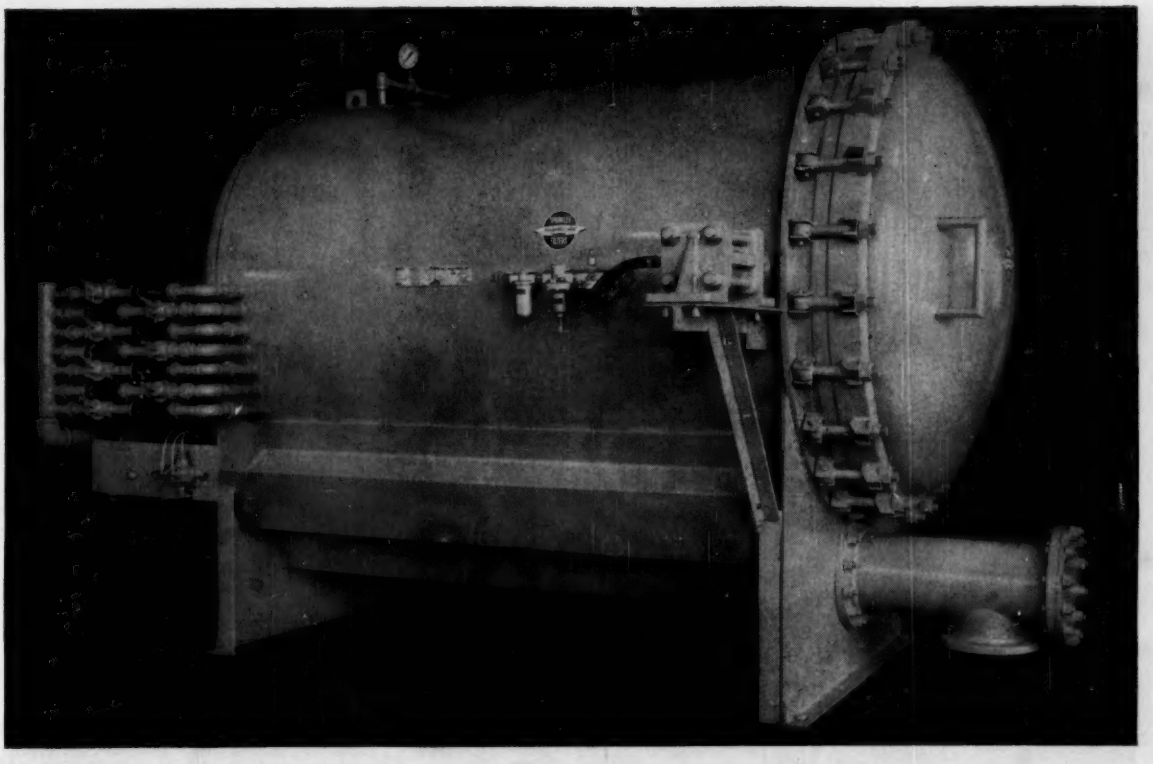


HEAT TRANSFER SPECIALISTS

Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario, Canada.

WOLVERINE TUBE
DIVISION OF
Calumet & Hecla, Inc.
DEPT. F, 17232 SOUTHFIELD RD., ALLEN PARK, MICH.
Manufacturers of Quality-Controlled Tubing

PLANTS IN DETROIT, MICHIGAN AND DECATUR ALABAMA.
SALES OFFICES IN PRINCIPAL CITIES



A NEW AUTOMATIC FILTER

Has horizontal plate cake stability plus automatic cake discharge

SPARKLER Model HRC

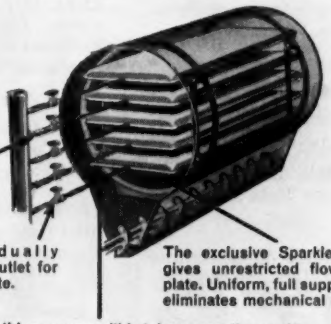
Filters with plates in horizontal position thus assuring complete cake stability, no danger of cake cracking or breakthrough under any operating condition or even with complete shut down.

To clean; cake is blown dry. Each plate operating with individually valved outlets and sight glass. Then plates are rotated to vertical position and the cake drops off with the aid of a vibrator and is expelled by a worm screw in the bottom of the tank in semi dry state or can be furnished without screw for liquid slurry discharge. The complete cleaning operation is performed without opening the filter, a completely enclosed system.

All operations of the filter including precoating and cleaning can be fully automated.

Write for complete information

Diagram of operating position of plates during precoating, filtering, and blow down. Horizontal position assures positive cake stability.



Sight glass for each plate is provided on outlet to give a continuous check on clarity during filtering and to determine when cake is dry during blow down.

Individually valved outlet for each plate.

The exclusive Sparkler plate construction gives unrestricted flow through the filter plate. Uniform, full support of the filter media eliminates mechanical breakage.

Flexible non-corrodible tube connecting each plate with individual outlet. Flexibility of this connection permits rotating of the plate assembly for cleaning.

Diagram of operating position of plates during cleaning, with plates rotated to a vertical position.

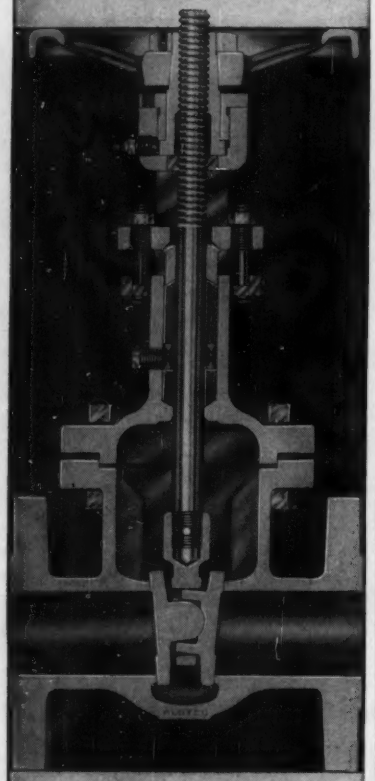
Dry cake falls off vertical position of plates and drops into trough bottom to be expelled with screw conveyor.

Vibrator rod connects through tank wall with linkage on plates to drop cake.

SPARKLER FILTERS

SPARKLER MANUFACTURING COMPANY · Conroe, Texas, U.S.A.

FOR HIGH-PRESSURE CORROSIVE SERVICE:



300 lb. Aloyco Stainless Steel Gate Valves

Figure 2117 double disc. (above) Available in sizes ½" to 8". Figure 2217 for solid wedge. Sizes ½" to 12". In addition—screwed, and socket weld ends. Sizes ½" to 2". Other 300 lb. designs including globes, swing and lift checks; jacketed and tank valves. 600 lb. designs also available.

Materials
Types 304 and 304L
Types 316 and 316L
Aloyco 20
Monel and nickel
Hastelloy alloys B and C

For more information on Aloyco valves for your specific corrosive service, write for Bulletin #7 to Alloy Steel Products Company, 1301 West Elizabeth Ave., Linden, New Jersey... the one manufacturer specializing in Stainless Steel Valves exclusively.

9.3

Longer Lasting ALOYCO VALVES

SUBSIDIARY OF WELWORTH

FIT IN CORROSIVE SERVICE

ALLOY STEEL PRODUCTS COMPANY
Linden, New Jersey

Convention Calendar

November

2-4. Society for Experimental Stress Analysis, Annual Meeting, Berkeley, Calif.

3-4. American Production and Inventory Control Society, 3rd Annual National Conference and Technical Exhibit, Sheraton-Cadillac Hotel, Detroit, Mich.

3-4. Louisiana Polytechnic Institute, School of Engineering, 9th Annual Instrumentation Conference, Ruston, La.

7. Society of Plastics Engineers, "Automation in Injection and Compression Molding", King Edward Sheraton Hotel, Toronto, Ont.

7-9. The Chemical Institute of Canada, Canadian Chemical Engineering Conference, Quebec City, Que.

8-10. The Material Handling Institute, Inc., Material Handling Institute Central States Show, The Kentucky Fair and Exposition Center, Louisville, Ky.

9-10. The Chemical Market Research Assn., Annual Meeting, Pittsburgh Hilton Hotel, Pittsburgh, Pa.

14-17. American Institute of Electrical Engineers, Magnetism & Magnetic Materials Meeting, New Yorker Hotel, New York, N. Y.

14-18. American Society of Tool Engineers, Western Tool Show & Semi-annual Convention, Ambassador Hotel, Los Angeles, Calif.

15-17. Building Research Institute, 1960 Fall Conference, Shoreham Hotel, Washington, D. C.

15-16. Purdue University, Symposium on Engineering Applications of Probability and Random Function Theory, Lafayette, Ind.

16-17. Oklahoma State University, Industrial Wastes Conference, Stillwater, Okla.

20-22. Fluid Controls Institute, Inc., Fall Meeting, Drake Hotel, Chicago, Ill.

29. American Institute of Consulting Engineers, Annual Dinner, Waldorf-Astoria Hotel, New York, N. Y.

29-30. Midwest Research Institute and CHEMICAL ENGINEERING Symposium on new techniques in mathematics, chemistry and engineering as applied to modern chemical engineering practice, Hotel Muehlebach, Kansas City, Mo.

27-2. American Society of Mechanical Engineers, Annual Meeting, Statler-Hilton Hotel, New York, N. Y.

28-2. American Society of Mechanical Engineers, 24th National Exposition of Power and Mechanical Engineering, New York Coliseum, New York, N. Y.

29-2. Corrosion and Metal Finishing Exhibition, Olympia, London, England.

30-2. The Iron and Steel Institute, Symposium on "Steels for Reactor Pressure Circuits", Hoare Memorial Hall, London, England.

December

1-2. Ohio State University, 21st Annual Conference on Glass Problems, Columbus, Ohio.

1-3. American Chemical Society, 16th Regional Meeting, Biltmore Hotel, Tulsa, Okla.

3-9. Chemical Specialties Manufacturers Assn., 47th Annual Meeting, Hollywood Beach Hotel, Hollywood, Fla.

4-7. American Institute of Chemical Engineers, Annual Meeting, Statler Hotel, Washington, D. C.

8. Synthetic Organic Chemical Manufacturers Assn., Annual Meeting, Hotel Roosevelt, New York, N. Y.

11-14. American Nuclear Society, 8th Hot Laboratory and Equipment Conference, Mark Hopkins Hotel, San Francisco, Calif.

11-14. Eastern Joint Computer Conference, New Yorker Hotel, New York, N. Y.

12-14. U. S. Public Health Service, National Conference, "Problems and Progress in Water Pollution Control," Sheraton-Park Hotel, "Washington, D. C.

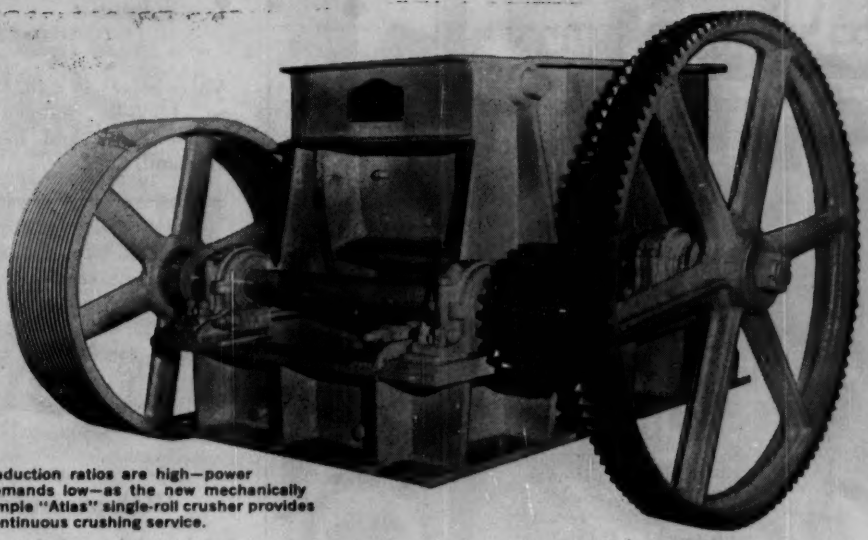
12-15. Industrial Building Exposition and Congress, New York Coliseum, New York, N. Y.

14-16. Atomic Industrial Forum, Annual Conference, Fairmont Hotel, San Francisco, Calif.

26-31. American Assn. for the Advancement of Science, Annual Meeting, New York, N. Y.

January

16-18. American Astronautical Society, 7th Annual Meeting and Convention, Sheraton-Dallas Hotel, Dallas.



Reduction ratios are high—power demands low—as the new mechanically simple "Atlas" single-roll crusher provides continuous crushing service.

NEW! PENNSYLVANIA "ATLAS" CRUSHER

offers economical, efficient reduction of shale, soft gypsum, soft limestone, chemicals, etc.

This new "Atlas" crusher is job-engineered for *economy, performance, capacity*—on crushing a variety of materials demanding machine ruggedness somewhat less than required in other crushing operations.

These are compact, powerful, single-roll machines that will give years of trouble-free crushing service at a cost of a fraction of a cent per ton. "Atlas" crushers fit well into production lines. They are built for continuous crushing, and can be started or stopped at any time.

Basically a primary crusher, with its 18, 24 or 30-inch roll diameters handling feeds of 14, 20 and 26 inches respectively, the "Atlas" also serves under many conditions as a secondary crusher.

CHECK THESE FEATURES

Low headroom requirements • Compact • Economical • Large capacity • Continuous crushing • Minimum of fines • Low power demand • Large receiving hopper • Minimum attention • One-pass, non-clog crushing • Wide range of size adjustment

With the addition of this new "Atlas", Pennsylvania now offers the widest range of single-roll crushers in the industry—permitting precise job-engineering of the exact machine for each application.

FREE BULLETIN

Full information and operating details on "Atlas" crushers are described in new Bulletin 2025. Send for a free copy today.

PENNSYLVANIA CRUSHER DIVISION
BATH IRON WORKS CORPORATION
WEST CHESTER, PENNA.

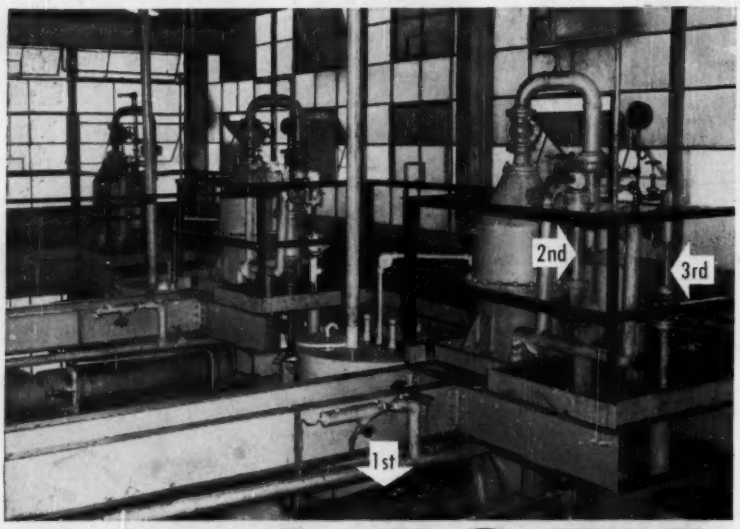
★ ★ ★

Over 50 years concentrated experience in all types of material reduction makes Pennsylvania your best source of crushers and engineering advice and service. Call on Pennsylvania with your next crushing problem. Representatives from coast-to-coast and abroad.

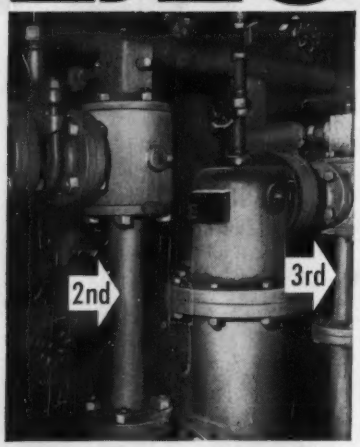
PENNSYLVANIA CRUSHERS

BATH-BUILT

ELLIOTT



EJECTORS



maintain low absolute pressure... help food processors remove objectionable odors and tastes

Three Elliott 3-stage steam jet ejectors, seen in upper photo, are serving deodorizers in a new food processing plant in Illinois. Two of the first-stage ejectors discharge to large Elliott barometric intercondensers which are served by two-stage ejectors. Photo at lower left shows close-up of second- and third-stage ejectors in deodorizer service.

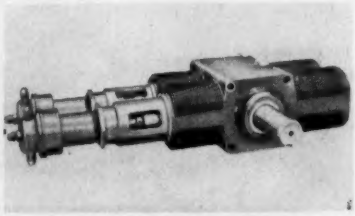
Deodorization is made possible since neutral fat cannot be vaporized, but the components of oil which impart unpleasant odors and flavors can be changed into vapors through steam distillation. This steam flowing through the oil acts as a carrier, sweeping the vapors out of the oil. Key to the process is creating low absolute pressure—accomplished by Elliott steam jet ejectors.

ELLIOTT Company
Jeannette, Pa.

GO-1

(Continued from page 78)

Valve comes in 2-in. size with 900 to 1,500-lb. flanged ratings.—**Grove Valve and Regulator Co., Oakland, Calif.** 78C



High-pressure pump

Lightweight unit handles LOX, other liquefied gases.

Low-boiling-point, liquefied gases, such as argon, oxygen, nitrogen and hydrogen, can be pressured to 15,000 psi. by a new cryogenic pump, said to be many times lighter than equivalent pumps. Weighing only 30 lb. (vs. up to 900 lb. for some pumps), unit may be either motor-driven or hydraulically operated.

At 3,000-psi. discharge pressure, pump has a positive suction-head requirement below 15 psi. for flow of 30,000 scfh. Motor-driven unit is close-coupled to save space. Pumps can be taken apart in 10 min. to service high-pressure components.—**Paul Chemical Co., Fullerton, Calif.** 158A

Drum-type cooler

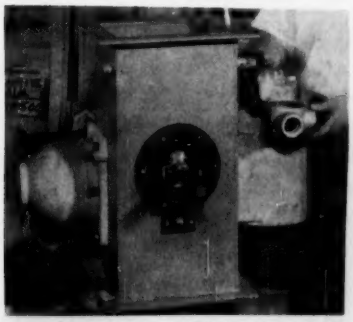
High-temperature fine solids are cooled in rotating cells.

A conduction-type drum cooler can handle fine materials at high temperature in a rotating drum, using a series of flat hollow fins or cells extending from drum's periphery.

The cells are in the form of a giant hollow screw conveyor with the horizontal drum acting as a shaft. Open to the drum, the cells form a continuous path that conveys entering material to the drum's exit end.

The drum revolves partly submerged in cooling water. Contact between the cells and the water is prolonged by baffles placed in the open spaces between the cells so that the water is scooped up and carried over the top of the drum with each revolution. Heat-transfer coefficients up to 20 Btu./hr.-sq. ft.-deg. F. are possible.

Solids that have been tested in the unit include gypsum plaster, granulated sugar, flue dust, cement, foundry sand, soybean flakes and others. A laboratory unit is available for testing hitherto untried solids.—**Link-Belt Co., Chicago.** 158B



Nuclear flow gage

Mass-flow density gage for dry solids uses beta radiation.

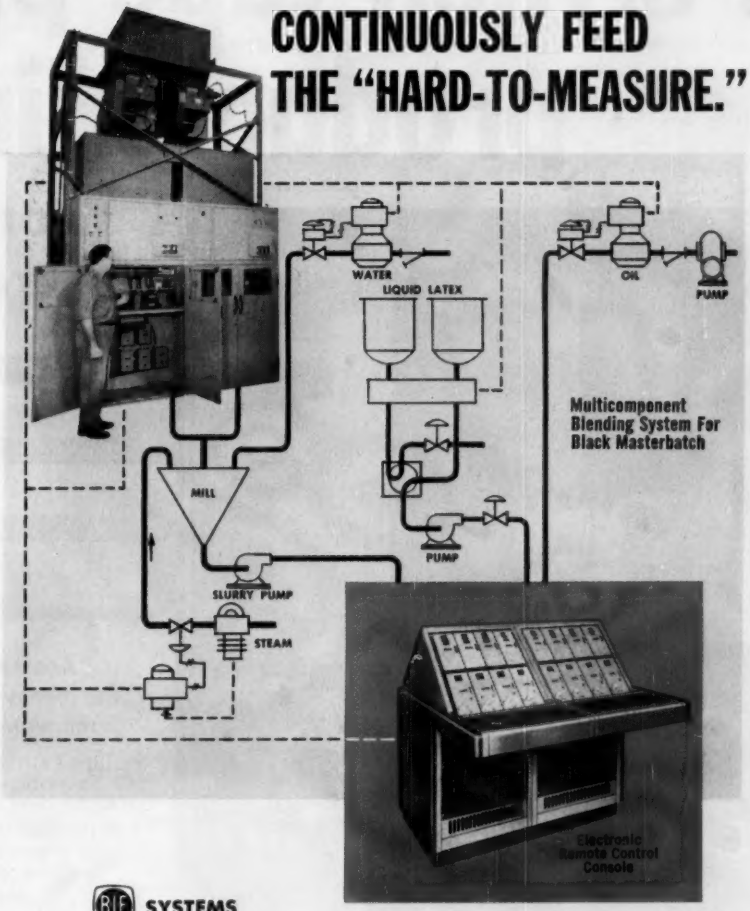
Formerly used only for measuring the level and density of liquids and slurries, a nuclear gage has now been designed to measure flow of solid materials. First application is in a cement plant although it is adaptable to any material whose specific gravity can be determined.

Operation of the gage is based on the fact that a beta ray hitting solid material causes X rays of various energies to be emitted. The amount of X radiation reaching a conversion cell on the other side of the material is determined by the amount of material passing a given point at any instant. Cell converts radiation directly to electrical current for measurement purposes.

Gage can be installed with

POSITIVE CONTROL OF *MATERIALS IN MOTION* B-I-F METERS FEEDERS CONTROLS

CONTINUOUSLY FEED THE "HARD-TO-MEASURE."



B-I-F SYSTEMS
PROVIDE NEW DIMENSION IN CONTINUOUS PROCESSING

For difficult processing problems involving hard-to-handle, hazardous or toxic materials, B-I-F offers "systems know-how" combined with 25 years field experience in feeding techniques.
B-I-F performance-proved, loss-in-weight feeding systems are currently being used for such difficult materials as: Carbon Black, Latex, Ammonium Perchlorate, Tetraethyl Lead, Catalysts, Food Additives and High Vapor Pressure Liquids.

Here's why:

- Materials are completely enclosed in feeding unit which can be pressurized with inert gas.
- Feeds any flowable solid or liquid material from 1 to 60,000 pounds per hour. Built-in rangeability to meet specification from 10 to 1 to 50 to 1 depending on material.
- Accuracy — ¼ of 1% by weight of set feed rate. Automatic feedback control loop prevents cumulative error.
- Proportional pacing by mechanical, electrical, pneumatic or electronic controls.
- Rate of feed may be controlled locally or remotely.
- No field calibration required.

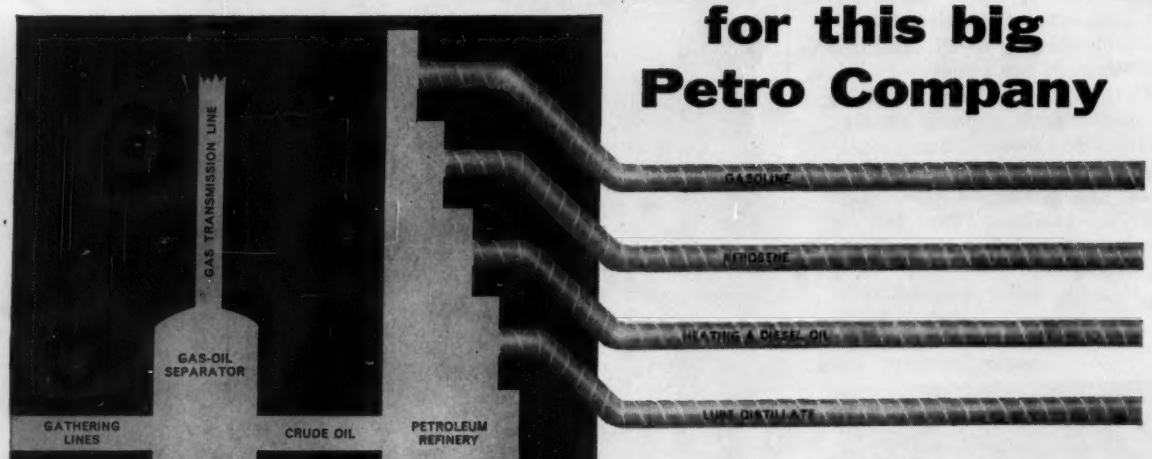
B-I-F Industries

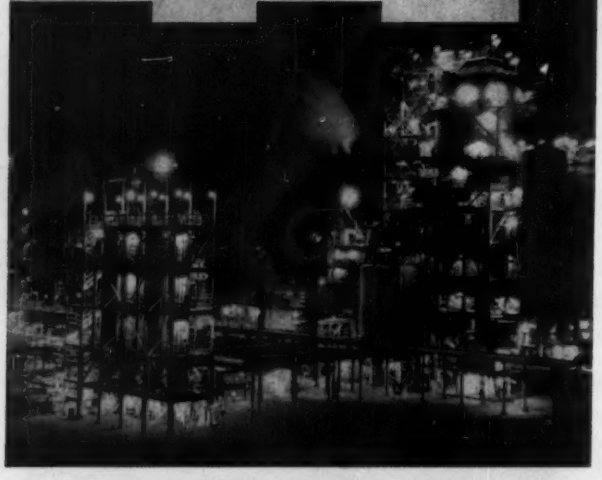
BUILDERS-PROVIDENCE • PROPORTIONEERS • OMEGA
METERS • FEEDERS • CONTROLS / CONTINUOUS PROCESS ENGINEERING

Continuous feeding can be your answer to greater processing efficiency. Request Bulletin 32-R2. Write **B-I-F Industries, Inc., 369 Harris Avenue, Providence 1, Rhode Island.**

Polyken tape protects products lines

for this big Petro Company





Phillips pipe is cleaned and wrapped by Brodie Construction Company in a single factory-smooth operation. No primer, no drying or cooling. No fumes or fire hazards.

Another convinced user learns the money-saving versatility of one of the world's incredibly tough tapes

Phillips Petroleum Company chose Polyken No. 960 Extra-Strength Pipeline Tape to protect its products lines. This is why:

- Polyken 960 is a *dependable* pipeline coating. It is easy to handle, simple to apply, resulting in a reliable, quality installation.
- It is *especially* suited to construction of short lines and close work, as on these pipelines carrying crude oil fractions.
- It utilizes high-density polyethylene for maximum durability and corrosion resistance.
- It stands up under tough conditions of terrain and climate—experience-proved in many, many thousands of squares installed throughout the world, in plains, deserts, mountains, swamps.
- Its cathodic protection requirements are low.

AND . . .

- It saves money: Polyken 960 goes on fast with less men per job, covers more miles per day. Less equipment, less handling costs. More savings over the old hot dope idea.

See your Polyken Man . . . call your Polyken Tape Coating Distributor . . . or write Polyken, 309 West Jackson Blvd., Chicago 6, Illinois.

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San Francisco, Calif.
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Seattle, Washington
Farwest Corrosion Control Corp.

Seattle, Washington
Pacific Water Works Supply Co.

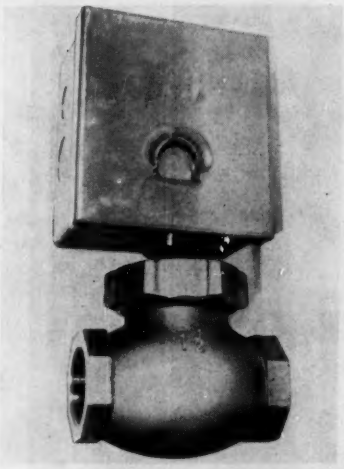
St. Louis, Missouri
Shutt Process Equipment Co.

Tulsa, Oklahoma
Midwestern Pipe Line Products Co.

Polyken

Experienced in modern PROTECTIVE COATINGS

either a point or strip radiation source. Beta sources (Strontium 90, in this case) are most effective for material velocities of about 10 ft./sec. Cost: about $4,500.—**The Ohmart Corp., Cincinnati.** 159A



Solenoid valve

Direct-acting unit is spring loaded for positive closing.

Included in the features offered in a new line of direct-acting solenoid valves are: full-area orifice, positive closing, solenoid protection in hinged electrical knockout box, and renewable composition discs.

For applications requiring large port, low-pressure valves, new units are available from ⅜ to 2½-in. They withstand pressures from 40 psi. in the smaller sizes to 4 psi. for large sizes.—**J. D. Gould Co., Indianapolis.** 161A

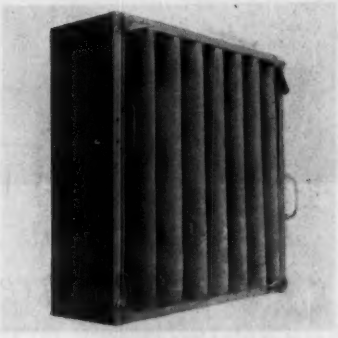
Power sweeper

Walk-behind unit clears 34-in. swath through abrasive dust.

Specially equipped for sweeping areas exposed to abrasive and conductive dusts, a new walk-behind sweeper travels at 3 mph. Self-propelled, it stops automatically when the operator releases the steering handle.

Unusual dust-protection features include: new dry-type air filter for the engine, full sealed electrical system to prevent ignition shorts when sweeping up conductive metal dusts, and special shielded and sealed dustproof bearings.

A 26-in. main brush revolves in a vacuum-equipped compartment, throws heavy soilage directly forward into a removable hopper. Simultaneously, a high-volume fan sucks up lighter dust into a fabric filter. An exposed side brush allows flush-with-wall sweeping. Sweeper is powered with 4-hp. air-cooled engine.—**G. H. Tennant Co., Minneapolis.** 161B



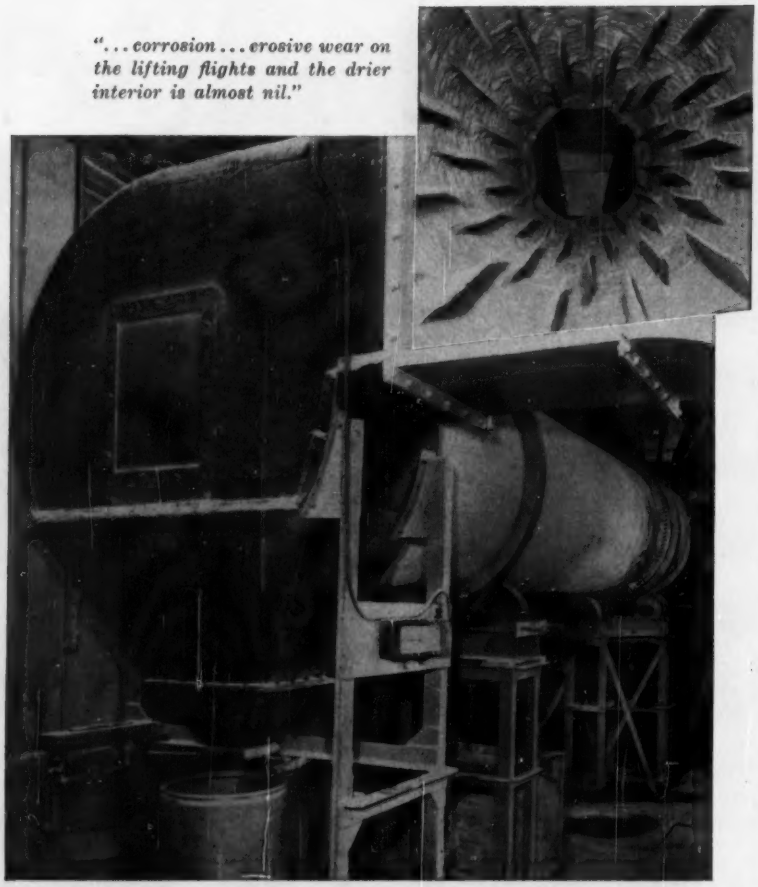
Air filter

Spongelike material has low pressure-drop, cleans easily.

Called Foamat, a single sheet of plastic material, pleated into a holding frame, is said to break an air stream into little jets as it passes through the filter. Dust and dirt are trapped in 30 to 80 cells/in., which give the media a large dust-holding capacity.

According to the manufacturer, Foamat will not pack, settle, separate or develop thin spots in service. Designed to act as a permanent filter, the dirt-laden plastic can usually be cleaned with a standard spray-head hose nozzle without removing the filter from the filter bank. For stubborn dusts, remove filter, soak in mild detergent, rinse with cold water, and replace.

"... corrosion ... erosive wear on the lifting flights and the drier interior is almost nil."



Dramatic New Application Proves DuVerre's Durability Under Punishing Corrosive Conditions

A novel solution to a severe corrosion problem in this continuous rotary drier was provided by du Verre resin bonded fiberglass construction. Wet HCL fumes resulted in extreme corrosion throughout the original alloy construction. Heat compounded the problem, with temperatures ranging from 225° F. to 290° F. It was vital to arrest corrosion to absolutely prevent product contamination.

As a test, a portion of the actual drier was fabricated by du Verre. The results were so conclusive that du Verre supplied a complete new drier, including the exit gas separator housing, gas entrance and product discharge housing and lifting flights. Today, after a year's service, the entire du Verre drier unit remains completely free of corrosion. In addition, erosive wear on the lifting flights and the drier interior is almost nil.

Light weight, du Verre is easy and inexpensive to install. Since du Verre is homogeneous (not a coating), it requires no painting or other maintenance. du Verre is entirely self-supporting; its structural rigidity does not depend on external reinforcing.

Investigate the many advantages of du Verre construction for ducts, stacks, hoods, tanks, trays and special units.

du Verre inc.

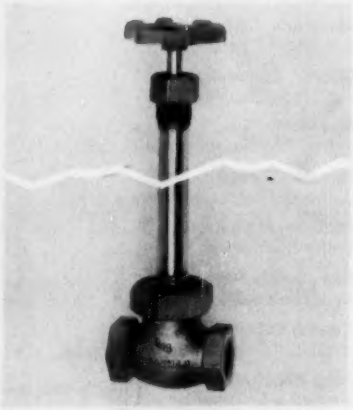
Write Today for Bulletin 101!

du Verre... First in Quality for Complete Corrosion Control with Reinforced Plastics.

BOX 37-A • ARCADE, NEW YORK

NEW EQUIPMENT . . .

Foamat is resistant to vermin and moisture, is chemically treated for permanent flame resistance. Standard 2-ft-square pleated unit has 17.5 sq. ft. of filtering surface, will pass 1,200 cfm.—**American Air Filter Co., Inc., Louisville, Ky. 161C**



Extended-bonnet valve

Bronze gate, globe, angle types vie for cryogenic service.

Liquid oxygen, hydrogen and nitrogen are handled by a new line of bronze valves ranging from ¼ to 3-in. size. Featuring extended bonnets (shown in cutaway view, above), new line uses Teflon-impregnated braided asbestos packing. Each valve is degreased and sealed to prevent contamination.

Operating temperature range is −300 to +100 F. Bonnet extensions (pipe centerline to handle) are 12, 15 and 18 in., depending on valve size. Extensions facilitate operation through thick layers of insulation.—**Stockham Valves and Fittings, Birmingham, Ala. 162A**

Briefs

Air-hammer kit contains paint scraper, scaling tool, routing and offset flat chisels for removing caked-on paint, chemicals and

other encrustations from tanks, drums, vats and mixing kettles. Metering trigger on hammer lets operator control tool blows/min. from 0 to 13,000 operating unit with one hand.—**Superior Pneumatic & Mfg., Inc., Cleveland.** 162B

Swench is rachet-type impact wrench that uses automatically delivered, spring-actuated rotary hammer blows to magnify torsional force applied to the handle. Principle of operation is said to give user precise control of the magnified force delivered to a nut or bolt.—**Curtiss-Wright Corp., Wood-Ridge, N. J.** 163A

Automatic blending system uses turbine meters and piston valves to control liquid flows for multichannel blending. General-purpose digital computer (G-15) controls and records flows and detects malfunctions in the system.—**Bendix Corp., Los Angeles.** 163B

Teflon Raschig rings resist buildup of sludges, suspended or precipitated solids and contamination products. Nonporous Teflon resists acids to 500 F. Sizes are from $\frac{3}{8}$ to $1\frac{1}{4}$-in. O.D. — **Resistoflex Corp., Roseland, N. J.** 163C

Scouring pads of stainless steel are washable and rustproof, provide soft yet firm texture for removing dirt, discoloration and foreign matter from process equipment without injury to the hands of the user.—**Terriss-Consolidated Industries, New York.** 163D

Small centrifugal pump is now available in Hastelloy B and C for service outside the realm of stainless steel. Mechanical seal of Teflon or carbon, in combination with ceramic or Hastelloy, is chemically inert. Capacities range to 35 gpm.—**Eco Engineering Co., Newark, N. J.** 163E

Glass-reinforced polyester tanks in capacities from 20 to 20,000 gal. are resistant to most acids, alkalies and bleaches at elevated temperatures. Lightweight construction materials (bisphenol-A poly-

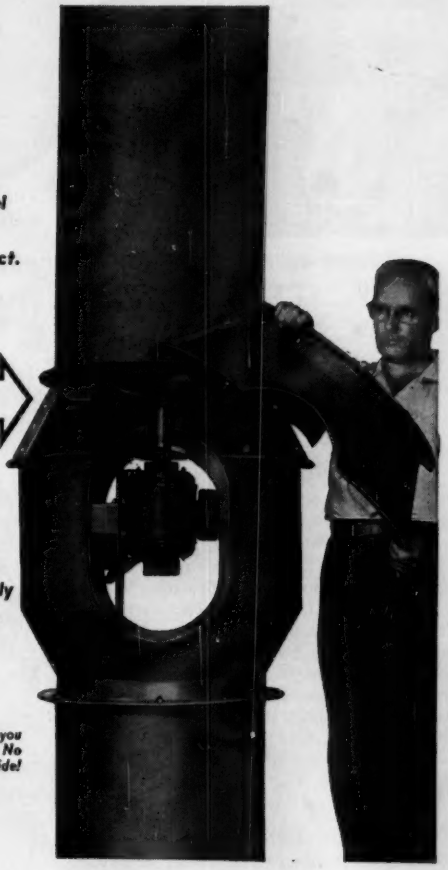
Now . . . pull the fan wheel or motor while DeBothezat® Bifurcator® Fan remains in duct.

Not just an access door. Half the entire cone comes off.

Speed up inspection . . . slash maintenance and downtime costs.

This removable cone design is an exclusive feature found only on DeBothezat Bifurcator Fans.

Published ratings on DeBothezat Fans tell you exactly what the complete fan unit puts out. No guess work — no allowance to be on safe side!



New design duct fan

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NOZZLE

with new advanced design

EXCLUSIVE SWIRL CHAMBER

The exclusive SDX swirl chamber has a single inlet spiral configuration which produces a natural, free vortex flow pattern. This pattern minimizes friction, adds to the nozzle's long life, and improves its spray characteristics. The special patented chamber is made of hardened stainless steel. The SDX's orifice disc and back plate are made of tungsten carbide, another feature which contributes to the nozzle's long life — a fact which has been proved in laboratory and field tests. The durable SDX is the ideal nozzle for highly abrasive materials.

BETTER ATOMIZATION

The SDX produces a uniform hollow cone spray pattern with exceptionally uniform particle size distribution. It has the added advantage of offering excellent atomization at lower operating pressures.

CERTIFIED PERFORMANCE

The flow rates on Delavan SDX nozzles are certified to be within ±5% of rated capacity, tested on water at 1000 psi. Spray angles are certified to be within ±5° of rated spray angle. This certification is your assurance that Delavan SDX nozzles will perform as rated.

WIDE CHOICE OF CAPACITIES AND SPRAY ANGLES

The SDX nozzle is available in a full range of flow rates, each rate furnished as standard in several spray angles. Matching the flow rate and spray angle in your dryer often means greater efficiency and a better end product.

Write for a copy of Delavan's descriptive Spray Drying Catalog.

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ester resin, glass fibers) make 1,000-gal. tank only ½ as heavy as equivalent stainless steel tank.—**Justin Enterprises, Inc., Cincinnati. 163F**

Proportional sampler has a slow-speed pumping unit which continuously delivers a liquid sample to a splitter box that reduces sample to desired size. Sample size and frequency are adjustable over a range of 2,000 to 1.—**Plasti-Fab, Portland, Ore. 164A**

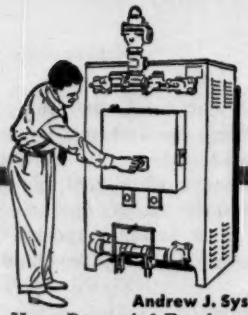
Disk-type check valve with one moving part opens at 2-8 psi., has calculated bursting pressure of 20,000 psi. Soft-surface disk is said to provide tight sealing at all pressures in air, oil, water service. —**Bodnar and McDermott Mfg. Co., Mount Vernon, N. Y. 164B**

Fiberglas platform ladder has aluminum steps, platform and fittings. It is a nonconductor of electricity, resists moisture and chemical attack. Available in platform heights from 4 to 10 ft.—**Aluminum Ladder Co., Florence, S. C. 164C**

Equipment Cost Indexes . . .

	June 1960	Sept. 1960
Industry		
Avg. of all	238.2	237.4
Process Industries		
Cement mfg.	232.8	231.7
Chemical	240.1	238.6
Clay products	226.2	225.6
Glass mfg.	226.6	225.3
Paint mfg.	229.8	229.1
Paper mfg.	231.3	229.9
Petroleum ind.	234.1	234.0
Rubber ind.	237.6	236.9
Process ind. avg.	236.5	236.2
Related Industries		
Elec. Power equip	242.7	240.2
Mining, milling	241.5	240.0
Refrigerating	268.5	267.7
Steam power	225.0	224.3

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124-6 for method of obtaining index numbers; April 4, 1960, pp. 149-50 for annual averages since 1913.



Andrew J. Syska,
Hayes Research & Development Engineer Reports . . .

KNOW-HOW IS VITAL IN GAS AND LIQUID DRYING

When we developed the Molecu-Dryer®—a unit specially designed to take advantage of the remarkable drying, sweetening, and purifying capabilities of Linde Company's Molecular Sieves—our chief interest was in drying protective atmospheres (hydrogen, dissociated ammonia, etc.) for metallurgical work —to dewpoints well below –100°F. A natural outgrowth of the Molecu-Dryer was the *Nitro-Gen*®—an automatic cycling generator which produces low cost, high purity nitrogen for blanketing, purging, protecting. Our engineering people have also explored whole new worlds of gas, liquid, and atmosphere drying and separating problems.

NEW DRYING NEEDS APPEAR DAILY

In manufacturing transistors, for example, the Molecu-Dryer has been able to effect big economies by supplying moisture-free air in place of tank nitrogen to protect transistor assembling and sealing operations. Other current projects: instrument air drying, gaseous CO_2 drying, gas separating . . . also drying and separating of liquid or gaseous hydrocarbons.

EQUIPMENT DESIGN IS DYNAMIC!

Each new area of work has necessitated engineered application of standard or special Molecu-Dryer models, to provide optimum adsorption efficiency, top capacity at minimum equipment cost, job-coordinated cycle times, and fast desorption and cooling.

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It pays to see HAYES for metallurgical guidance, laboratory facilities, furnaces, atmosphere generators, gas/fluid dryers.

One-stage purification delivers

ETHYLENE WITH LESS THAN 1PPM OF CO_2

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This is only one of many applications which utilize the high capacity and selectivity of LINDE Molecular Sieves. In fact, Molecular Sieves not only outperform other adsorbents, but do other adsorption jobs never before accomplished. Whether in new installations or as replacement adsorbent in existing units, Molecular Sieves can help you minimize both investment and operating costs. More specifically, here's how they are used. . . .

A major petrochemical company has reduced the CO_2 content of its ethylene from 3000 PPM to less than 1PPM. This high purity is achieved in a single-stage process, automatic and non-corrosive, which has proved to be more economical than the alternative four-stage process. Other petrochemical uses include drying of cracked gases, ethylene, hydrogen, liquid propylene, solvents and many other gases and liquids. **Natural gas producers** use Molecular Sieves for drying and sweetening of natural gas, for sweetening of liquid propane and butane, and for drying of adsorber oil. **Petroleum refiners** use them to gain efficiency in drying reformer hydrogen, liquid butane LPG and transformer oil, and for removal of impurities such as CO_2 and mercaptans. **Refrigeration manufacturers** use Molecular Sieves as a desiccant in super-drying refrigerants to eliminate freeze-up and corrosion.

For these and many other adsorbent applications, you can rely on patented LINDE Molecular Sieves to perform more effectively. They are the top quality material of their kind available today, always uniform, with high capacity, high strength, and high bulk density. They are available in regular and special grades to meet your specifications.

LINDE technical know-how—gained from years of laboratory and field work with adsorption problems—can help make Molecular Sieves work profitably for you. For further information, write: Dept. **CE-105**, Linde Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. **In Canada:** Linde Company, Division of Union Carbide Canada Limited, Toronto 7, Canada.

SOME AREAS WHERE MOLECULAR SIEVES IMPROVE ADSORPTION

- Purification of ethylene
- Drying gases, liquids, solvents
- Drying, sweetening natural gas
- Sweetening liquid propane, butane
- Drying jet fuels
- Octane improvement
- As refrigerant desiccant
- Controlled atmosphere purification

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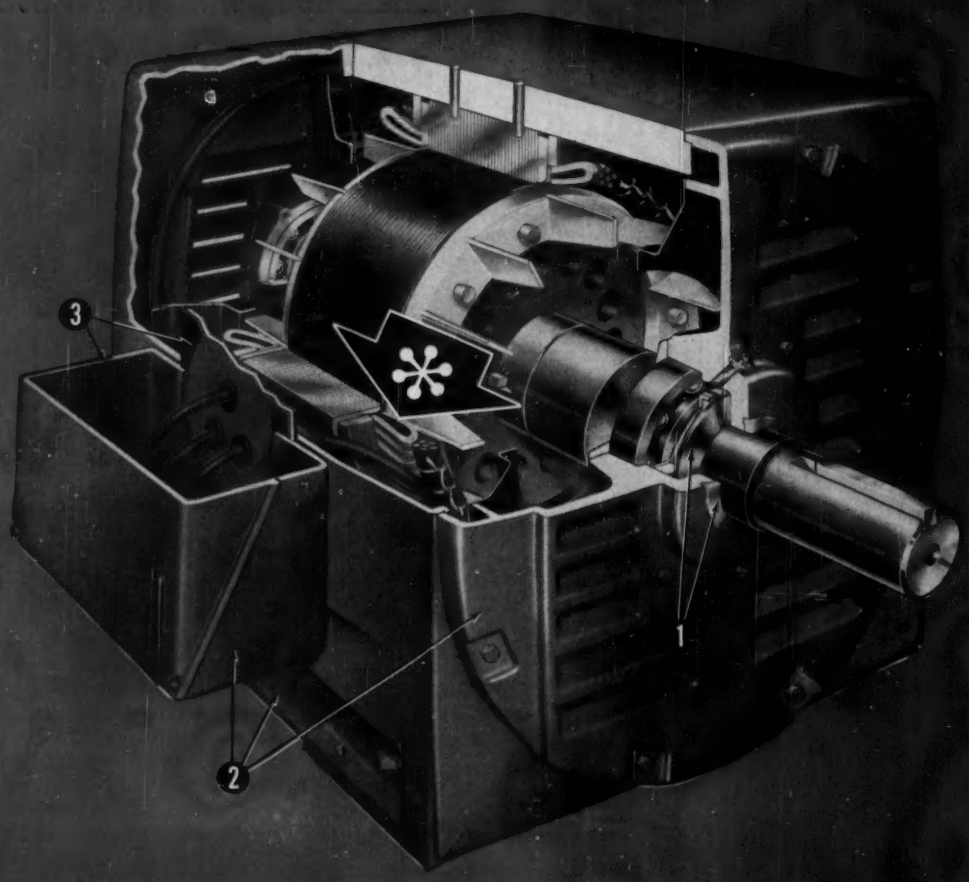
General Electric's CUSTOM '8000' means . . .*

MOTORS CUSTOM DESIGNED FOR THE CHEMICAL INDUSTRY



1 CUSTOMIZED BEARING SEALS guard CUSTOM '8000' motor bearings against the alkalies, acids, salts and other contaminants encountered in chemical processing applications.

2 FRAME, END SHIELDS, AND CONDUIT BOX are cast iron. All other parts and hardware are specially treated for corrosion resistance to provide maximum reliability in moisture-laden and corrosive atmospheres.

3 EXTRA-LARGE CAST IRON CONDUIT BOX has gaskets at the split, and between frame and box to seal out moisture. Leads enter box through rubber grommets to seal out ambient air.

IN ADDITION TO THE SPECIALIZED MOTOR FEATURES mentioned above, General Electric CUSTOM '8000' motors offer these superior "standard" features: easily-removable, lightweight, flat end shields simplify motor maintenance; "positive-purging" lubrication system increases bearing life—prevents grease leakage along shaft (new sleeve bearing design also available); pre-wound stator core assures uniform high performance; acoustic design reduces motor noise level.

CUSTOM '8000' MOTORS are manufactured to the rigid quality specifications General Electric has adhered to for over 80 years. Today, with the implementation of advanced design and manufacturing techniques, G.E. can accurately and economically *Customize* motors to your specific requirements through utilization of motor components engineered exclusively for chemical processing applications.

** Trade-mark of General Electric Co.*

MEDIUM AC MOTOR AND GENERATOR DEPARTMENT

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EXCLUSIVE

POLYSEAL * INSULATION SYSTEM LENGTHENS MOTOR LIFE

General Electric's new Polyseal supported silicone rubber insulation system is designed to give maximum winding protection against damage from the alkalies, acids, salts and other contaminants encountered in the chemical processing industry.

The Polyseal system assures superior mechanical, thermal, voltage and environmental endurance. This form-wound insulation is a vulcanized system "built-up" from silicone rubber tape reinforced by glass and Dacron† fabric. Polyseal both retains its resilience and provides a positive seal against fluids and other chemical processing contaminents.

POSITIVE MOISTURE PROTECTION is assured by "under water" production line tests. For example, 2300-volt, form-wound Polyseal coils are water soaked for one-half hour—then "hi-potted" at 8000-volts while still completely immersed—to prove the insulation system is absolutely sealed.

† *Registered Trade-mark DuPont Co.*

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for full information on CUSTOM '8000' motors for the chemical industry, or write for Bulletins GEA-6865 and GEA-6889, to Section 884-11, General Electric Company, Schenectady 5, New York.

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Technical Bookshelf

Processes and Practices

From all of the recently published technical books, here's a gleaning of those devoted to handbooks and references. Our comments are noncritical, capsule reviews suggesting scope of the books' contents. Purpose is to alert you and all chemical engineers to the availability of these new monographs.—HSG

"The art of molding originated with prehistoric man."

Third edition of the Plastics Engineering Handbook, official volume of the Society of the Plastics Industry, Inc., is now at hand. Intended as "a definitive guide to the plastics industry," the new edition contains twenty-six sections, including ones on design of molds and dies, reinforced plastics, vinyl dispersions, cold molding. There is a chapter on nomenclature, and latest developments in decorating and welding are detailed. Two pullout-insert tables comprise: (1) classification of rigid molding materials, (2) reference chart of adhesives. (Plastics Engineering Handbook. 3rd edition. Ed. by the Society of the Plastics Industry, Inc. Reinhold Publishing Corp., New York. 850 pages. $15.)

"Absorption . . . probably most important . . . technique."

The subject of gas purification is well covered in this volume, which provides factual descriptions, methods and other useful working data for the design of process units and plants. *CE* readers may recall a 52-page preview report that appeared in the June 15, 1959 issue. New book is the complete, comprehensive text. (Gas Purification. By A. L. Kohl and F. C. Riesenfeld. McGraw-Hill Book Co., New York. 556 pages. $15.)

"Petroleum is the . . . organic remains of plants and animals."

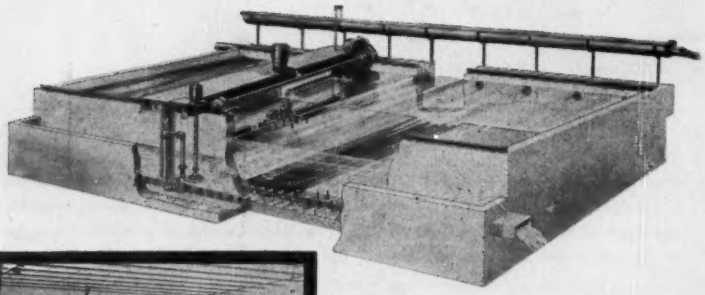
Intended for "advanced students and young research workers," this introduction to petroleum technology stresses application of thermodynamics in solving problems of hydrocarbon chemistry. It covers current standards and practices of the petroleum industry—including origin and chemical constituents of petroleum, physical properties, production processes, products, uses and byproducts. Bulk of the volume is devoted to production and refining; petrochemicals get 20-page mention at the end. (Chemical Technology of Petroleum. 3rd edition. By W. A. Gruse and D. R. Stevens. McGraw-Hill Book Co., New York. 675 pages. $15.)

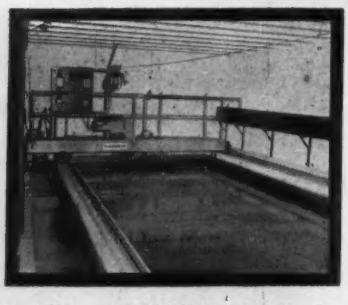
"Corrosion . . . phenomenon that follows no set pattern."

Easy-to-follow text considers composition, physical and mechanical properties, fabrication techniques, design and typical use of each material covered. Information is presented in nontechnical manner, and the author authoritatively appraises as he goes, interpreting from his own practical experience, without making references to the literature. (Materials Selection for Process Plants. By R. E. Gackenbach. Reinhold Publishing Corp., New York. 318 pages. $8.50.)

"The chemical engineer recognizes design as his responsibility."

This popular reference is now out in a 4th edition. Much of the material has been rearranged (e.g., the first six chapters detail the chronological development of a chemical process) and many additional graphic aids have been included. Of the 118 illustrations, only 22 were taken from the previous edition. (Chemical Engineering Plant Design. 4th edition. By F. C. Vilbrandt and C. E. Dryden. McGraw-Hill Book Co., New York. 534 pages. $12.)





12½' x 40' Hardinge Automatic Backwash Sand Filter in a municipal water plant in Vermont.

12½' x 86' Hardinge Filter handling water supply for a Canadian paper plant.

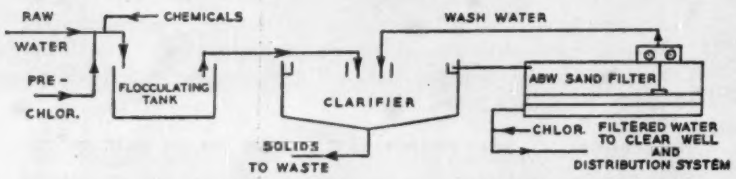
A sand filter for **CONTINUOUS** *Water Supply*

The Hardinge Automatic Backwash Sand Filter is a complete departure from standard filtration equipment, in that it backwashes its filter bed automatically without interrupting normal filtration.

The ABW filter in combination with flocculation and sedimentation equipment provides an uninterrupted supply of treated and filtered water for municipal and industrial use.

The secret of it's operation lies in a traveling backwash carriage which cleans one filter bed compartment at a time for reuse or disposal.

Complete specifications upon request. Bulletin 46-A-11.



The flow sheet above illustrates the use of a Hardinge ABW Filter, in conjunction with Hardinge flocculating and clarifying equipment, on municipal or industrial water treatment.

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In Rapid Review

Physical Methods of Organic Chemistry. Part I (in four parts—3rd ed.). Ed. by A. Weissberger. Interscience Publishers, New York. 894 pages. $24.50. First volume of the revised edition of the well-known ten-volume series, this comprises treatment of the topics related to fundamental properties of matter, such as density, temperature, molecular weight, melting and boiling point, solubility, viscosity, surface and interface phenomena, osmotic pressure, as well as automatic control and recording.

X-Ray Spectrochemical Analysis. By L. S. Birks. Interscience Publishers, New York. 137 pages. $5.75. A concisely written booklet—Volume 11 in the series "Chemical Analysis"— this will serve to give an up-to-date accounting of X-ray spectrochemical analysis to the research scientist. It also will be very instructive to technicians already familiar with X-ray techniques and to scientists and engineers who have incidental interest in the apparatus, the method and its applications.

Non-Benzenoid Aromatic Compounds. Ed. by D. Ginsburg. Interscience Publishers, New York. 543 pages. $18. The noted contributors to this volume have thoroughly reviewed the synthetic pathways to the nonbenzenoid aromatic compounds and have provided excellent discussions on the nature of aromaticity, the peculiar chemical reactions of this class of compounds, and the comparison between theoretical treatments and actual properties. Book is well documented with over 1,600 up-to-date literature references.

Quantum Chemistry—Methods and Applications. By R. Daudel, R. Lefebvre, and C. Moser. Interscience Publishers, New York. 572 pages. $14.50. Written by a group of internationally known experts, this book is intended for those who might wish to know how to calculate wave functions of molecules and how to use these functions to study some of their physical and chemical properties.

The Merck Index. 7th ed. Ed. by G. Stecher, et al. Merck & Co., Inc., Rahway, N. J. 1,641 pages. $12. The completely new 7th edition of the familiar index contains over 1,600 pages of text, covering nearly 10,000 descriptions of individual substances, more than 3,300 structural formulas, and about 30,000 names of chemicals and drugs alphabetically arranged and cross-indexed. It is an essential reference book for the practicing medicinal chemist.

Modern Coordination Chemistry. Ed. by J. Lewis and R. G. Wilkins. Inter-

science Publishers, New York. 487 pages. $12.50. The past 20 years have witnessed a tremendous rekindling of interest in the chemistry of coordination compounds since quantum mechanics opened greater insight into this field. The present book contains contributed chapters on the thermodynamics, reaction rates of transitional complexes; isomerism; visible, ultraviolet and infrared spectra; and magnetochemistry of coordination complex compounds.

Pyridine and Its Derivatives. Part 1. Ed. by E. Klingsberg. Interscience Publishers, New York. 613 pages. $49. Volume 14 of the series "The Chemistry of Heterocyclic Compounds" has been divided into four parts because of the vast amount of literature on pyridines. Part 1 covers physical and chemical properties of pyridine, partially hydrogenated pyridines, natural sources of the pyridine ring, pyridines by degradation of natural products, and synthetic methods for preparation of pyridines.

Lipide Chemistry. By D. J. Hanahan. John Wiley and Sons, New York. 330 pages. $10. First of a pair, this volume concerns itself primarily with recent progress in the isolation, purification and chemistry of the simple and complex lipids and lipoproteins of mammals. The nature of the association of lipids with proteins receives consideration. A companion volume, entitled *Lipide Metabolism*, edited by K. Bloch, is on press.

Advances in Organic Chemistry: Methods and Results. Vol. 1. Ed. by R. A. Raphael, E. C. Taylor and H. Wynberg. Interscience Publishers, New York. 387 pages. $12. First in a contemplated series, this volume presents articles dealing with new aspects, and novel extensions to well-established methods, in organic chemistry. Each chapter contains a discussion of the scope and limitations of the subject under consideration, and in most instances experimental conditions and procedures are presented.

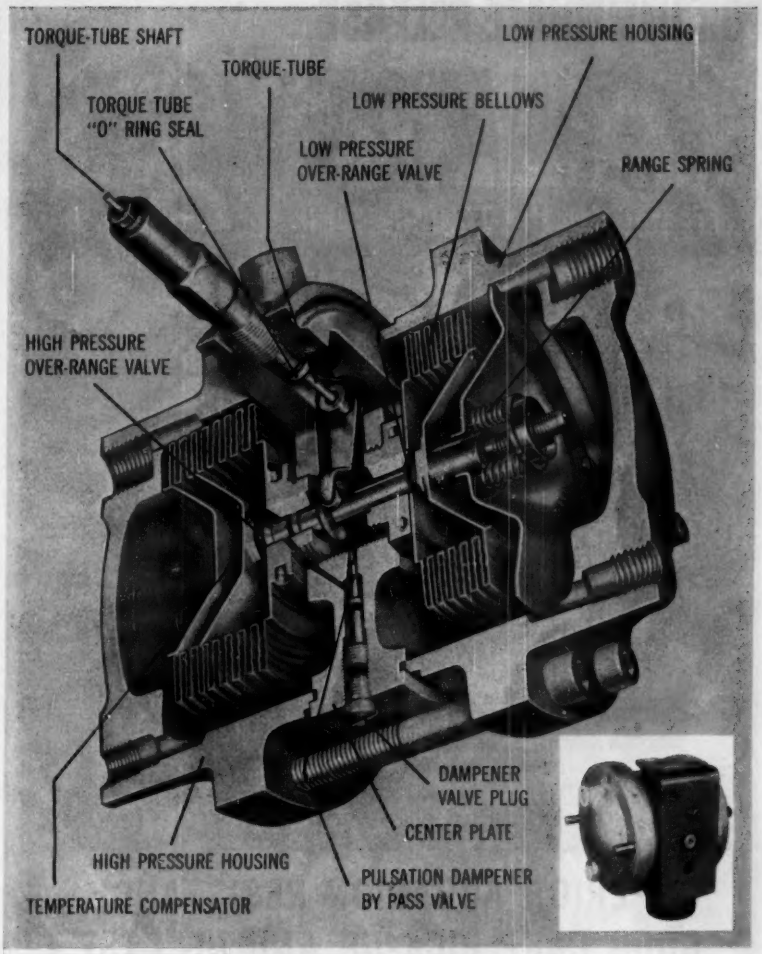
More New Books

Elementary Theoretical Fluid Mechanics. By Karl Brenkert, Jr. Wiley. $7.50.

Runnerless Molding. By E. P. Moslo. Reinhold. $4.95.

Pulp and Paper. Vol. I, 2nd ed. By J. P. Casey. Interscience. $19.50.

Progress in Dielectrics. Vol. II. Ed. by J. B. Birks & J. H. Schulman. Wiley. $9.50.



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The exclusive Barton rupture-proof dual bellows meter is not affected by overranging, maintains calibration and requires minimum maintenance.

Built-in ability to withstand violent line surges, yet immediate response to the slightest differential pressure or level changes – that's the Barton rupture-proof 199 meter body. Proved in countless demanding installations, the 199 meter body is the heart of an entire line of precise instruments that includes controllers, indicators, recorders, integrators, transmitters and switches. The 199 meter body features such refinements as temperature compensation for maximum stability, adjustable pulsation dampener for positive response control, top and bottom pressure taps for self-draining and easy venting. The 199 is available in a full range of differential pressures up to 50 psi and static pressure ratings up to 6,000 psi. For the ultimate in dependability, accuracy and minimum maintenance, specify Barton.

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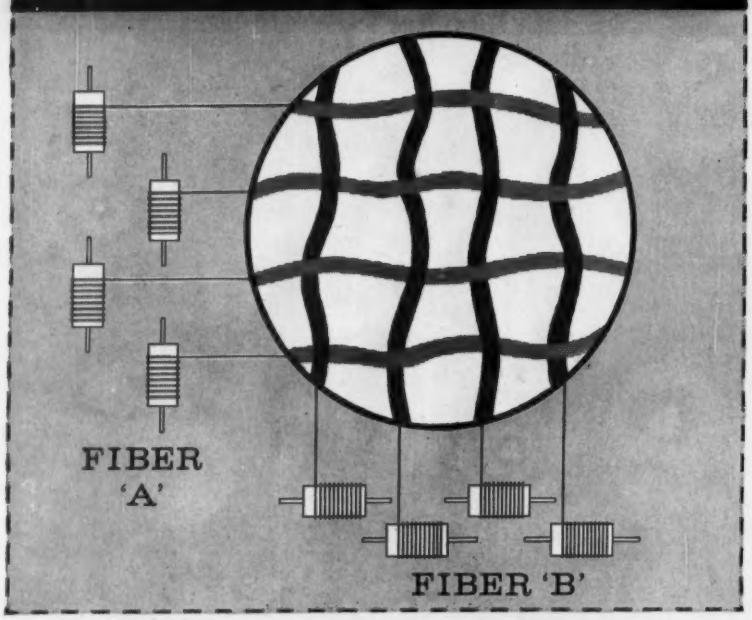

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Letters: Pro & Con

Pro: Silicones Article

Sir:

We have had a request for a quantity of reprints of the article, "Silicones Solve Problems," on p. 156 of your Aug. 22 issue.

I would like to note that Mr. Brennan's handling of this piece was very well received here, and I have heard nothing but favorable comments concerning it. I trust it will be of great benefit to your readers. I know it will do considerable service in providing a better understanding of the silicone industry and the versatility of products currently available.

L. W. MAHAR
General Electric Co.
Waterford, N. Y.

Pro: Prof. Natta

Sir:

Your June 27 *Process Flowsheet* (pp. 96-99) describing the operation of Humble's polypropylene plant at Baytown, Tex., was headlined, "Polypropylene by the Ziegler Process." In the article, you mentioned that, among other polypropylene plants now on stream or on the way, using Ziegler chemistry, there is the plant of Montecatini's Novamont subsidiary.

Both the headline and this statement seem misleading. The first scientist to produce commercially usable polypropylene was Prof. Natta of the Polytechnic of Milan,

and there is no doubt that Novamont's plant will use Natta's inventions and chemistry as industrially developed by Montecatini.

Montecatini was one of the earliest licensees of Prof. Ziegler's invention of complex organometallic catalysts and the possibility of using such catalysts to polymerize ethylene. Shortly after this disclosure, Prof. Natta, Montecatini's consultant, working with Ziegler-type catalysts, discovered sterically differentiated polypropylene, and somewhat later he discovered stereospecific catalysis and invented his stereospecific propylene polymerization processes.

Both Ziegler and Natta are outstanding scientists, but let us give credit to each of them where it belongs.

MARIO L. OTTOLENGHI
Novamont Corp.
New York, N. Y.

Pro: Ribbon Blenders

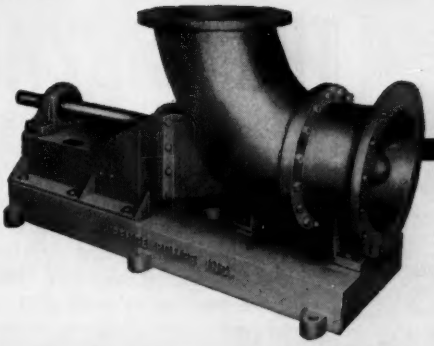
Sir:

Congratulations on your excellent report on Solid-Solid Blending (Aug. 8, pp. 107-128).

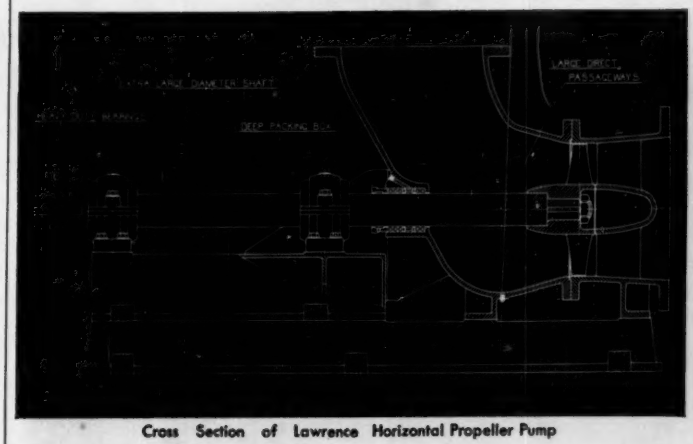
However, I take exception to the statement that the ribbon blender is not in the same class as the twin-shell unit. The twin-shell blender is a modified tumbling barrel with its axis reversed and a half shell added to enhance its mixing characteristics. Mr. Fischer compared this most sophisticated of tumbling barrels with a rudimentary ribbon blender. In fairness, it should be compared to the very sophisticated modern ribbon machines available today.

Modern ribbon blenders can be used on slurries and can be operated continuously. Because they do not depend on a situation of random distribution due to gravity forces, control during blending is excellent.

The blending examples in Mr. Fischer's article did not include an operation where a material tends to agglomerate with itself in the presence of other ingredients. No amount of tumbling can overcome this. This type of operation re-



Lawrence 24" Horizontal Circulating Pump of Nickel Alloy Construction



Cross Section of Lawrence Horizontal Propeller Pump

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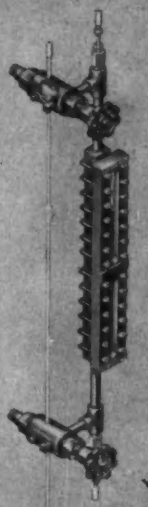

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quires a certain amount of smearing on the unit walls in order to accomplish good blending.

There was little consideration given to that rather large group of solid-solid blends that require heat transfer during blending. Whether it be heating or cooling, the configuration in a ribbon unit, with its constantly contacted transfer surfaces, is more effective than the intermittent contact in any type of tumbling machine.

These are only some of the highlights which I believe your presentation lacked concerning the use of ribbon blenders.

ALEXANDER A. MCINTYRE
Sperry Rand Co.
New Holland, Pa.

Making Corrections

Sir:

I would like to make two comments about *Chemical Engineering*. On the "pro" side, I have appreciated, in general, the changes introduced during past years. The arrangement of articles such that one does not end and another begin on the same sheet is a particularly desirable feature.

On the "con" side, I would like to propose a more positive method of bringing corrections of previous articles to the attention of your readers. Few things can cause a reader to lose faith in a journal more quickly than the knowledge that articles published therein may contain inaccuracies. From a practical point of view, however, it is inevitable that errors (typographical and otherwise) will be made in some of the many articles published each year.

If we agree that errors are inevitable, then we must also agree that published corrections are indispensable. In many journals, such corrections seem to be inserted haphazardly at the end of other articles or buried on a back page.

Could you publish corrections in a specified section of each issue? Knowing where to look would make it a simple matter for the reader to clip and retain all corrections and to make appropriate revisions in filed articles at his convenience.

CHARLES D. JOHNSON
Arthur G. McKee Co.
Cleveland, Ohio

▶ *We do have a regular place for publishing corrections. On those rare occasions when they're necessary we publish them in this department as letters to the editor. The only exception is that occasionally a correction concerning a specific editorial department (e.g., Chementator, Plant Notebook) may appear in a subsequent issue of the same department.*—ED.

Engineer or Manager?

Sir:

Your article, "That Other Grass Is Always Greener" (July 25, pp. 127-130), was very interesting.

But the survey that you report overlooked a very important point. It assumed equal qualifications for either engineering or management. It may be flattering to believe that one is as well qualified for management as he is for engineering, but if all who responded to the survey were tested, I'd guess that some of the best engineers would make the poorest managers, and some of the poorer engineers would probably never get the chance to show they could be good managers.

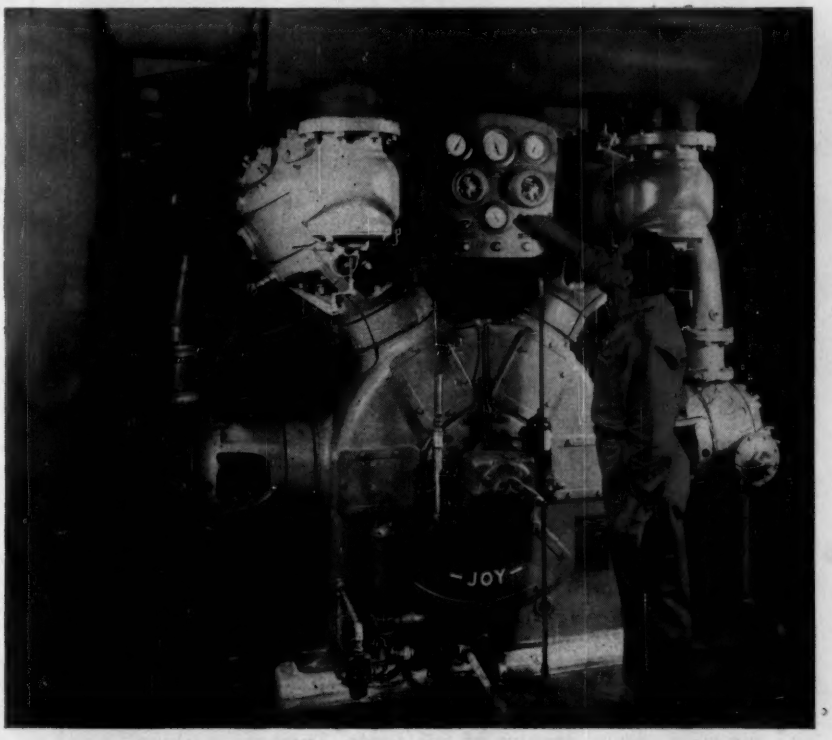
It is evident from the survey that engineers and engineering managers view things from different perspectives. Is every engineer who cherishes the hope of becoming a manager going to change his viewpoint, or is he going to try to revolutionize management single-handedly by changing the management concept?

It is surprising that the survey turned up so little difference between union and nonunion answers. The effect of unionism is toward more regimentation and less individualism. Maybe the same could be said of the status of the P.E. designation.

A. E. JURS, JR.
Shand & Jurs Co.
Berkeley, Calif.

FOR CRITICAL INSTRUMENT AND PROCESS AIR REQUIREMENTS

JOY OIL-FREE COMPRESSORS



One of five Joy WNOL 114E oil-free compressors installed at a large mid-western brewery. Each 200 hp machine supplies 1100 cfm at 90 psi.

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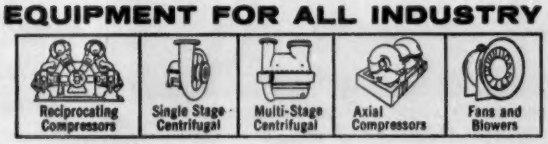

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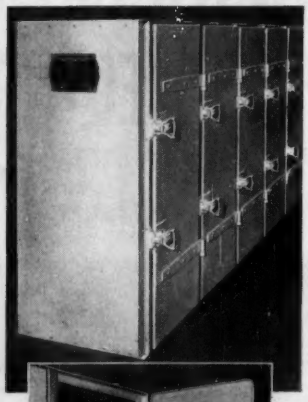

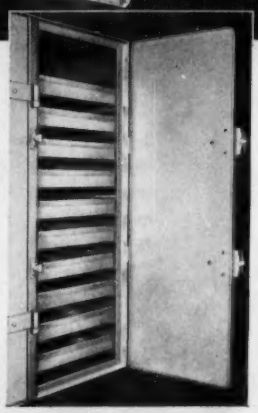

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Manufacturers' Literature

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Chemicals

Alumina.....White Data Sheets detail properties of each grade of Alcoa Alumina available to speed your own product development activity. Copy on request.
123 *Aluminum Co. of America

Catalyst Carriers.....Macroport "A" are currently available as spheres, pellets, and aggregate of fused aluminum oxide. Complete details on Macroport "A" carriers.
87 *Norton Company

Chemicals.....High quality ketones, alcohols, and intermediates, coupled with technical assistance to surface-coating formulators. Information about the many chemicals.
Cover *Shell Chemical Co.

Custom Synthesis.....Catalog lists formulae and simplified molecular structure diagrams of sixty-five production chemicals and sixty-seven developmental chemicals.
174A Elanco Products Co.

Dry Sulfamic Acid Product.....can now be obtained for removal of lime scale deposits from evaporative condensers and cooling tower systems. No. 1645.
79-80g *U.S. Industrial Chemicals Co.

Floor Protection.....Literature describes faster, less expensive way to protect and renew concrete and wood floors with epoxy plastic against many problem chemicals.
174B Steelcote Mfg. Co.

Hydrogen Gas.....Produced at low cost, and with low initial investment, from commercial anhydrous ammonia using a new adsorption process described in bulletin.
174C The Electric Furnace Co.

Industrial Mine Wastes.....Research on acid mine drainage problems has developed information that is given in paper "The Oxidation of Pyritic Conglomerates".
174D Mellon Institute

* From advertisement, this issue.

Lignosulfonates.....Booklet describes material used as dispersing, binding and chelating agent. Molecular structure, physical characteristics and analyses given.
175A Marathon Chemical Co.

Mold Compounds.....Answers to basic questions about the nature, purpose and performance of cold setting flexible mold compounds given in bulletin.
175B Smooth-On Mfg. Co.

Molecular Sieves.....are always uniform, with high capacity, high strength, and high bulk density. Available in regular & special grades to meet your specifications.
165 *Linde Co., Div. of Union Carbide

Organphosphites.....Bulletin 80 covers in detail triphenyl phosphite, diphenyldecyl phosphite, phenyldidecyl phosphite, & tridecyl phosphite. Includes specifications.
203 *Hooker Chemical Corp.

Polyethylene.....Formulation recently developed for extrusion-coating of paper described in bulletin that gives data on equipment, properties and coating conditions.
175C Eastman Chemical Products Inc.

Resins.....20-page booklet includes explanation supplemented with graphic and tabular data on the selection of the proper blend of resins to achieve desired balance.
175D Rohm & Haas Co.

Shielding Metals.....Brochure contains data on comparative costs analyses, and on corrosion resistance with about 150 acids and chemicals of lead surfaced metal.
175E Knapp Mills Inc.

Sight Glasses.....Bulletin contains property data and installation information on sight glasses used in such places as absorption columns, reaction kettles etc.
175F Corning Glass Works

Silicone Anti-Foam.....Anti-Foam 60 kills foam without affecting the other properties of your process. Disperses instantly in aqueous systems. Sample.
4 *General Electric Co.

* From advertisement, this issue.

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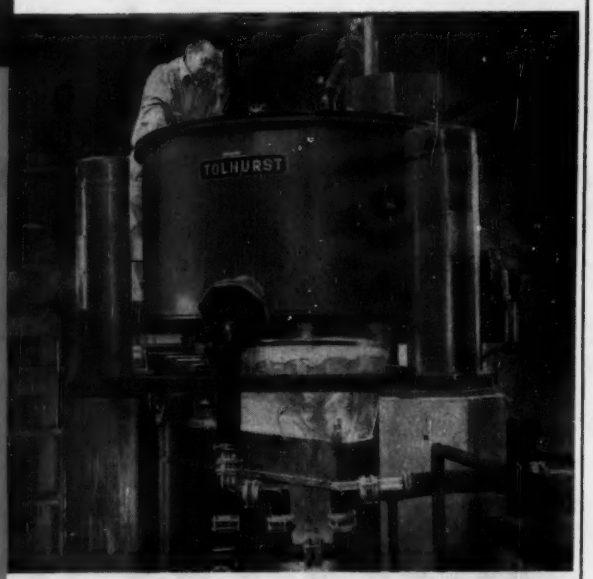

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LITERATURE . . .

Sodium Handling.....All phases of sodium handling are discussed in the latest edition of U.S.I.'s brochure "Handling Metallic Sodium on a Plant Scale".
79-80b *U. S. Industrial Chemicals Co.

Sodium Peroxide.....is covered in new data sheet giving specifications, typical analysis, properties, shipping data & uses. Information in No. 1643.
79-80e *U. S. Industrial Chemicals Co.

m-Sulfobenzoic Acid.....new intermediate for dyes, colors, color developers & couplers, surfactants, textile treating agents, flavors, drugs, etc. Data Sheet.
79-80j *U. S. Industrial Chemicals Co.

Thermoplastic.....Booklet rates Penton's performance when exposed to over 280 different chemicals & chemical reagents. Also a copy of "The Penton Buyer's Guide".
28-29 *Hercules Powder Co., Inc.

Urethane Elastomers.....New group now offered for use where abrasion resistance is essential. Suggested for chute linings, pipe-line crawler wheels, scrapers, etc.
79-80a *U. S. Industrial Chemicals Co.

Wet-Process Phosphoric Acid.....A new process to make granular diammonium phosphate fertilizer is being developed. Process being adapted to various grades.
79-80c *U. S. Industrial Chemicals Co.

Construction Material

Fabrication.....Corrosion problems solved through resin bonded fiberglass construction. Process equipment such as ducts, stacks, hoods, etc. Facts in Bul. 101.
162 *du Verre Inc.

Filter Medium.....Neva-Clog available in double layer, perforated, alloy sheet medium. Smooth, strong, rigid for diatomite filters, centrifuges, other. Catalog 57.
L190b *Multi-Metal Wire Cloth Co., Inc.

Floors.....Engineered Floors to withstand impact, thermal shock, abrasion and expansion without cracking or spalling. A complete flooring package available.
152 *The Ceilcote Co., Inc.

Hard Surfacing....Alloys and methods can protect your equipment. The Spraywelder Catalog and the Colmonoy Hard-Surfacing Manual are available on request.
T201 *Wall Colmonoy Corp.

Insulation.....New Calsilite-Hi for soaking heat to 1800 F. Ideal for both insulation & fireproofing. Additional specifications & samples available on request.
51 *The Ruberoid Co.

Lead Products.....These products include chemical lead sheets to your requirements; pipe, bends, traps & standard flittings. Bul. 162, the Lead Handbook for the CPI.
73 *American Smelting & Refining

Mechanical Seals.....16-page data booklet on seal selection describes various types available and their application under various conditions of service.
176A Goulds Pumps, Inc.

* From advertisement, this issue.

LITERATURE . . .

Nickel Alloys.....Documentation for the use of Monel & Inconel alloys in handling fluorine & its compounds can be obtained easily in 24-page booklet.
147 *International Nickel Co., Inc.

Propective Coatings.....Polyken 960 is a dependable pipeline coating. Easy to handle, simple to apply, & its cathodic protection requirements are low. Details on request.
160 *The Kendall Co.

Stainless Steel.....ELC grades make it possible to assemble or repair equipment in the field by welding. Information available on their cost-reducing use in chem. plants.
149 *Armco Steel Corp.

Silicone Insulation.....Silicone insulation systems made with Silastic silicone rubber is ideal for any location. New brochure on Silicone Insulation is available.
75 *Dow Corning Corp.

Tank & Pressure Vessels.....Large capacity vessels & tanks of mild stainless or alloy clad steel for petro-chemical, butane, petroleum & pulp industries. 16-pg. Catalog.
TR202 *Posey Iron Works Inc.

Wire Cloth & Filter Cloth.....Available in all alloys, weaves and meshes in sizes up to 244" wide. Roll or cut to size. Details available in Catalog 57.
490a *Multi-Metal Wire Cloth Co. Inc.

Electrical & Mechanical

Electro-magnetic drives.....12-page booklet describes how drives work, what they include and where they are used. In addition, the various types are discussed.
177A Westinghouse Electric Corp.

Expansion Joints.....Three types of expansion joints are available; Corrufiex Packless, Ram-Pak, and Slip Type. Comprehensive catalogs are available.
21 *Yuba Consolidated Industries

Explosion-proof Electrical Devices..... Catalog lists nearly everything you could want for hazardous areas. Explosion-proof telephones, horns, clocks, instrument closures, etc.
40 *Crouse-Hinds

Lighting Unit....The Intenso "Quartzlite 600" is ideal for signboards, displays, outdoor sports, building security, mobile equipment, storage areas & many other uses.
1 *Appleton Electric Co.

Motors.....Custom "8000 motors are easily-removable & lightweight. Frame, end shields, and conduit box are cast iron. Feature customized bearing seals.
166 *General Electric Co.

Semiconductors.....20-page catalog details complete and current product line; contains information on electrical and physical parameters of transistors, rectifiers etc.
177B Hoffman Electronics Corp.

Speed Reducers.....36-page booklet describes completely redesigned and expanded line of "balanced design" parallel shaft reducers in 57 sizes including 23 new sizes.
177C Link-Belt Co.

* From advertisement, this issue.

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FEinc custom designs every filter for a specific application. This insures greater yield with less downtime over longer periods of continuous operation. Standard sizes range from 5 to 800 sq. ft. of filtering area.

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FE INC®

LITERATURE . . .

Handling & Packaging

Bucket Elevators.....Complete line includes 14 types in 4 basic designs . . . centrifugal, positive, continuous, & internal discharge. Factory-aligned compenents available.
12 *Link-Belt Co.

Check Weighing.....Systems covered in bulletin can be applied to all types of dry or liquid, single or multi unit containers for a continuous check on filling accuracy.
178A Weighing & Controls, Inc.

Conveyor Drives.....adaptable to conveyors of all types, agitators, screw conveyors, machines & for any other transmission of power. Illustrated catalogs.
133 *Morse Chain Co.

Drums, Stainless Steel.....Choice of drums in 30- & 55-gal. capacities with removable heads; with tight heads, 55 gal. High resistance to corrosion. Full specifications.
13 *Pressed Steel Tank Co.

Feeders.....Bulletin contains detailed description of feeder for continuous feeding of large quantities of dry materials. Includes performance specifications and dimensions.
178B B-I-F Industries

Feeding Systems.....Loss-in-weight feeding systems are currently being used for such difficult materials as Carbon Black, Latex, Ammonium Perchlorate, etc. Bul. 32-R2.
159 *B-I-F Industries, Inc.

Insulation.....A copy of the Foamglas Insulation Catalog & the Armour Fact Sheet offered. Data Sheets on the complete line of accessory materials for use with Foamglas.
16 *Pittsburgh Corning Corp.

Leverage System.....guaranteed accurate for the life of the scale. Literature on its application to filling batching and checkweighing operations is available.
150 *Thayer Scale Corp.

Liquid Disposal Cans.....with large receiving spout for easy waste liquid disposal. Flam arrester protection at receiving opening. Details in "Red Book".
186e *The Protectoseal Co.

Pneumatic System.....The complete story on the savings with a Pneumatic System for a particular problem is contained in Bulletin I-54 which is available on request.
144a *Sprout, Waldron & Co., Inc.

Safety Storage & Dispensing Cans..... Oval shape require less space. Flame arrester protection at all openings. "Red Book" contains flammables engineering data.
186c *The Protectoseal Co.

Safety Tilt Can Assemblies.....easily tilted for accurate, dripless dispensing from self-closing faucet. Can returns to vertical position when released. "Red Book".
186d *The Protectoseal Co.

Scales.....Printweigh are available in a wide range of models including Portable, Floor & Bench types, Built-in Hopper, Overhead Track & Motor Truck types. Bul. 2017.
182 *Toledo Scale Corp.

* From advertisement, this issue.

LITERATURE . . .

Heating & Cooling

Equipment.....Bul. E-1 shows designs in heat exchangers, reactors, oil chillers, crystallizers, pressure vessels, steam generators & ice making & refrigerating machinery.
90 *Henry Vogt Machine Co.

Fan Sets.....Ready Units are ideally suited for supply or exhaust jobs, indoor or outdoors. Catalog 517 contains 36 pgs. of information, selector charts, dimensions, etc.
183 *Clarage Fan Co.

General Catalog.....32-page catalog covers radiators, heat exchangers, super-charger air coolers, industrial and oil field equipment and heating and air conditioning products.
179A Young Radiator Co.

Heat Exchanger.....Information about the P-12 Plate Heat Exchanger as well as a wide range of plate heat exchangers for a variety of applications is available on request.
6-7a *The De Laval Separator Co.

Ovens.....for unmatched drying quality. Bench, Cabinet, Truck and Conveyor types offer convection heating for fast, uniform heat processing. Bulletin 127.
B201 *W. S. Rockwell Co.

Panelcoil.....Complete technical data and pricing on Panelcoil can be found in Data Sheet 15-60 Series and in Price Bulletin 259 which is available on request.
TL202 *Dean Products, Inc.

Instruments & Controls

Analyzer.....The new BillionAire Analyzer is the hypersensitive instrument. New bulletin as well as other process stream analyzer literature is offered.
18-19 *Mine Safety Appliances Co.

Controls, Remote.....Crown Hydra-Trol remote controls are self-contained, manual-hydraulic positioning devices. Standard MAR & MAT type controls are described.
179B General Controls Co.

Diaphragm Seals.....for protection of pressure instruments against corrosion and clogging are illustrated and described in Bulletin 250. Covers all models.
179C Brooks Rotameter Co.

Heated Gages & Valves.....are built to meet the special conditions present when working with liquids which must be kept at higher than ambiet temperatures. Catalog.
172 *Jerguson Gage & Valve Co.

Indicators.....The SS Series is a complete line of compact measuring instruments for draft, pressure, differential gas pressure and temperature. Bul. MSP-121.
179D Hagan Chemicals & Controls

Level Control.....Electr-O-Probes are available in three models; B-04 super-sensitive relay, B-05 general purpose relay, and B-06 self-contained. Bulletins.
T200 *Instruments, Inc.

* From advertisement, this issue.

FEON®

specialists in LIQUID SOLIDS separation

By Centrifugal Extraction • Pressure Leaf and Continuous Vacuum or Pressure Filtration • Filter Media

GENERIC NAME, DEFINITION AND TRADE NAMES OF MAN-MADE FIBERS

GENERIC NAME	FTC DEFINITION	TRADE NAME
Acetate	—a manufactured fiber in which the fiber-forming substance is cellulose acetate. Where not less than 92% of the hydroxyl groups are acetylated, the term triacetate may be used as a generic description of the fiber.	ACELE[11] CELANESE[1] ESTRON[14] Also made and sold under generic name by 4, 5, 6, 9, 21 & 25
Acrylic	—a manufactured fiber in which the fiber-forming substance is any long chain synthetic polymer composed of at least 85% by weight of acrylonitrile units ($-CH_2-\underset{CN}{CH}-$).	ACRILAN[3] CRESLAN[4] ORLON[11] ZEFRAN[13]
Azlon	—a manufactured fiber in which the fiber-forming substance is composed of any regenerated naturally occurring proteins.	No current commercial domestic production
Glass	—a manufactured fiber in which the fiber-forming substance is glass.	FIBERGLAS[24] Also made and sold under generic name by 14, 22 & 27
Metallic	—a manufactured fiber composed of metal, plastic-coated metal, metal-coated plastic, or a core completely covered by metal.	FILDOR[11] LUREX[16] METLON[25] RAYMET[26]
Modacrylic	—a manufactured fiber in which the fiber-forming substance is any long chain synthetic polymer composed of less than 85% but at least 35% by weight of acrylonitrile units ($-CH_2-\underset{CN}{CH}-$).	DYNEL[11] VEREL[13]
Nylon	—a manufactured fiber in which the fiber-forming substance is any long chain synthetic polyamide having recurring amide groups ($-\overset{O}{\overset{\|}{C}}-NH-$) as an integral part of the polymer chain.	Made and sold under generic name by 2, 4, 8, 12 & 21
Nytril	—a manufactured fiber containing at least 85% of a long chain polymer of vinylidene dinitrile ($-CH_2-C(CN)_2-$) where the vinylidene dinitrile content is no less than every other unit in the polymer chain.	DARVAN[19]
Olefin	—a manufactured fiber in which the fiber-forming substance is any long chain synthetic polymer composed of at least 85% by weight of ethylene, propylene, or other olefin units.	AVISCOPE[1] REEVON[18] ROYALENE[18] WYNENE[24] Also made and sold under generic name by 20
Polyester	—a manufactured fiber in which the fiber-forming substance is any long chain synthetic polymer composed of at least 85% by weight of an ester of a dihydric alcohol and terephthalic acid (p-HOOC - C_6H_4 - COOH).	DACRON[13] KODEL[14] TERON[13] VYCRON[5]
Rayon	—a manufactured fiber composed of regenerated cellulose, as well as manufactured fibers composed of regenerated cellulose in which substituents have replaced not more than 15% of the hydrogens of the hydroxyl groups.	BEMBERG[3] CORDURA[13] CORVAL[7] FORTISAN[7] TYREX Also made and sold under generic name by 4, 5, 7, 21, 23 & 30
Rubber	—a manufactured fiber in which the fiber-forming substance is comprised of natural or synthetic rubber.	
Saran	—a manufactured fiber in which the fiber-forming substance is any long chain synthetic polymer composed of at least 80% by weight of vinylidene chloride units ($-CH_2-CCl_2-$).	Made and sold under generic name by 11, 16, 18 & 24
Spandex	—a manufactured fiber in which the fiber-forming substance is a long chain synthetic polymer comprised of at least 85% of a segmented polyurethane.	LYCRA[13] VYRENE[26]
Vinal	—a manufactured fiber in which the fiber-forming substance is any long chain synthetic polymer composed of at least 50% by weight of vinyl alcohol units ($-CH_2-CHOH-$), and in which the total of the vinyl alcohol units and any one or more of the various acetal units is at least 85% by weight of the fiber.	Limited production by 1
Vinyon	—a manufactured fiber in which the fiber-forming substance is any long chain synthetic polymer composed of at least 85% by weight of vinyl chloride units ($-CH_2-CHCl-$).	Made and sold under generic name by 5 & 31

1 Air Reduction Chemical Co.
2 Allied Chemical Corp.
3 American Cyanamid Co.
4 American Enka Corp.
5 American Viscose Corp.
6 Bemont Mills, Inc.
7 Celanese Corp. of America
8 Chemstrand Corp.
9 Courtaulds (Alabama) Inc.
10 Dobeckmun Co.
11 Dow Chemical Co.
12 E. I. du Pont de Nemours & Co., Inc.
13 Eastman Chemical Products, Inc.
14 Firth Corp.
15 Fiber Industries, Inc.
16 Firestone Plastics Co.
17 Freydberg Bros-Strauss
18 General Tire & Rubber Co.
19 B. F. Goodrich Chemical Co.
20 Hercules Powder Co., Inc.
21 Industrial Rayon Corp.
22 Johns-Manville Fiber Glass, Inc.
23 Merlon Corp.
24 National Plastic Products Co.
25 North American Rayon Corp.
26 Owens-Corning Fiberglas Corp.
27 Pittsburgh Plate Glass Co.
28 Reeves Brothers, Inc.
29 Reynolds Metals Co.
30 Shenandoah Rayon Corp.
31 Union Carbide Chemicals Co.
32 U. S. Rubber Co.

A DIVISION OF American Machine and Metals, Inc. FEON®
EAST MOLINE, ILLINOIS

Free reprints of this chart sent upon request

What are you paying for SPRAYING?

EXAMPLE:
Spraco Full-Cone Free-Flow Nozzles — for high capacity, low pressure installations

Spraco full-cone, free-flow nozzle discharging 860 gpm at 5 psi. At this shutter speed (1/5,000 sec.) pump pulsations are apparent in the spray pattern

To answer a long felt processing need, Spraco recently developed a totally new line of full-cone, free-flow nozzles for high capacity, low pressure installations where clogging is a problem and a full-cone spray a necessity. Featuring streamlined internal vane construction with maximum vane openings, they offer minimal flow resistance, virtually eliminate clogging.

Now widely used in cooling towers, coke quenching, aerating and purifying water supplies, and a host of chemical processing applications, Spraco Full-Cone Free-Flow nozzles are another excellent example of how Spraco cuts the cost of spraying by increasing the efficiency of the system.

What's your spray nozzle problem? Spraco offers the most complete range of nozzle sizes and capacities available anywhere, always in stock, and made from bronze, cast iron, stainless steel, or, to order, from any special machineable material.

Write today for the most comprehensive spray nozzle catalog ever published. Complete, accurate performance data for each of the hundreds of spray nozzles in the line.

SPRAY ENGINEERING COMPANY, *115 Cambridge Street, Burlington, Mass.*

SPRACO

LITERATURE . . .

Meter Body.....The rupture-proof 199 meter body is available in a full range of differential pressures up to 50 psi & static pressure ratings up to 6,000 psi.
169 *Barton Instrument Corp.

Meters.....The Kent Rotary Shunt Meter is an entirely self-contained unit for measuring the flow of steam, air, gas or water in pipe lines. Publication 939C.
180A Energy Control Co., Inc.

Pressure Elements.....are available from stock in ranges through 6000 PSI, for flow recorders, pressure recorders, indicators, transmitters, and switches. Bul. 60-P-1.
180B Industrial Instrument Corp.

Recorder.....Bulletin 418 provides details on chart recorder for flow, pressure and temperature measurements. Chart speeds are available from ½ inch to 6 inches per hour.
180C American Meter Co.

Regulators.....Bulletin 130 discusses pressure regulators with maximum inlet pressure of 1200 psi and maximum outlet pressure of 150 psi for reducing, relief and back pressure.
180D American Meter Co.

Transmitter.....Both power & signal travel over the same pair of unshielded wires in the electronic d/p cell transmitter. Complete details in Bul. 21-10.
57 *The Foxboro Co.

Pipe, Fittings, Valves

Piping.....Bondstrand is available in sizes from 2" through 8" with all necessary couplings & fittings. Bulletin containing complete data, including physical properties.
139 *Amercoat Corp.

Swivel Joints.....for practically all petrochemical & chemical services. Sizes from ¾" to 12" diameter in steel & from 3" to 12" diameter in aluminum. Catalog.
53 *Continental-Emsco Co.

Valve.....Bulletin describe dual-purpose hot water balancing valve, that can take the place of two valves normally used in series on the return line of a water coil.
180E American Air Filter Co.

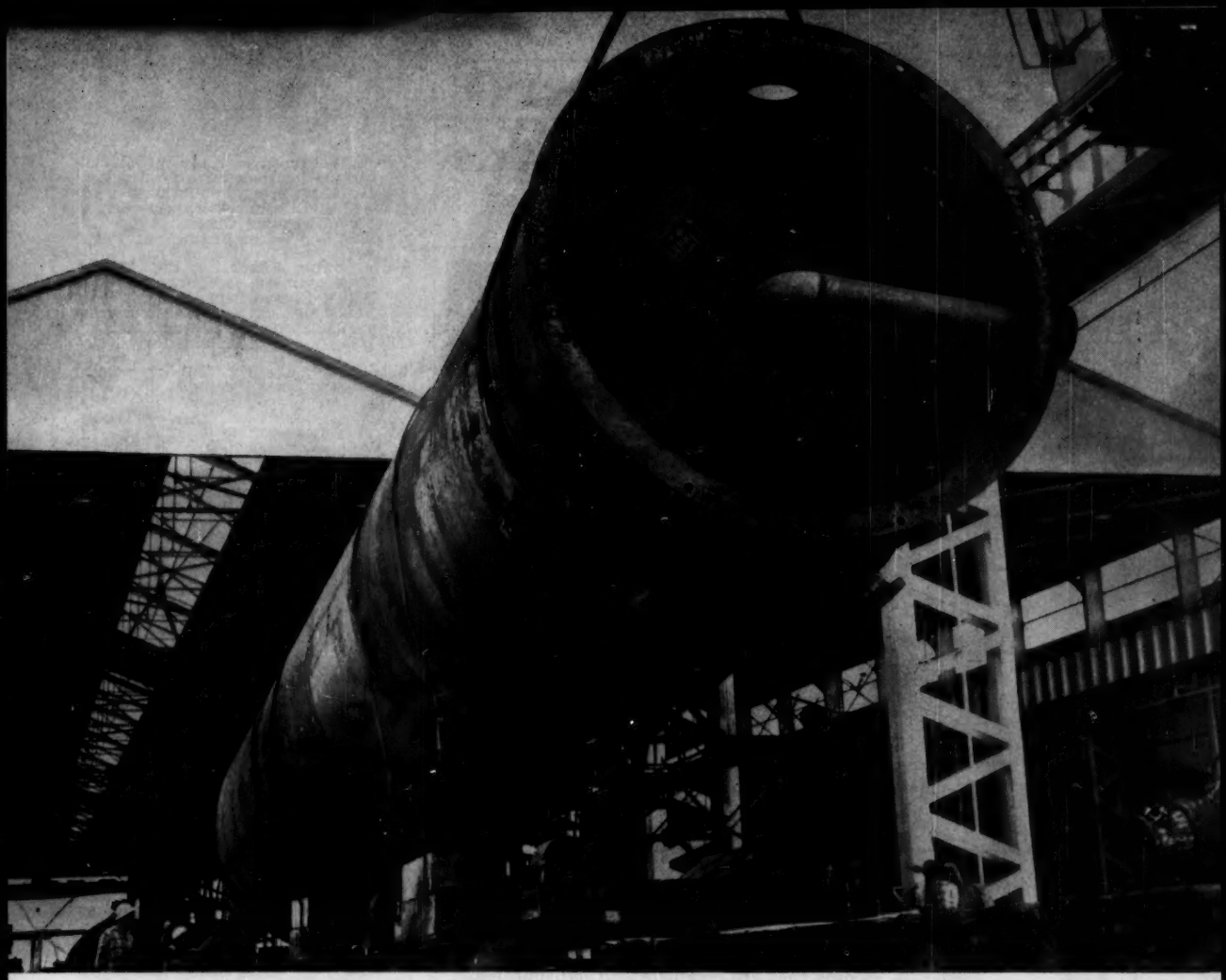
Valve.....available in ¼" through 6", 150 & 300 psi, straighway & 3 way. Alloys include carbon steel, 316SS, Durimet-30, Monel, Nickel, Chlorimet-2 & Chlorimet-3. Bul. V/14.
137 *The Duriron Co., Inc.

Valves & Fittings.....Circular describes in detail various products available in corrosion-resistant polyvinyl chloride for use in chemical and food processing industries.
180F Walworth Co.

Valve, Gate.....Fig. 2453SG large stainless steel O.S. & Y. for 150 W.P. Fully guided solid wedge disc. Available with interchangeable split wedg disc Fig. 2453DG.
125a *The Wm. Powell Co.

Valves Solenoid.....Direct-lift, full-ported economy valves designed for reliable operation to 1500 psi is described in bulletin that gives specifications and prices.
180G Atkomatic Valve Co.

* From advertisement, this issue.



Designed by the Fluor Corporation, Ltd., for the Union Texas Natural Gas Corp.

It took a stork's big brother to deliver this 225-ton baby

High-capacity cranes were needed to handle this giant absorber unit (225 tons, 56′ long, 4″ shell), that required special attention and equipment all along the way. First, it was made of ASTM A212 Grade B Firebox Quality Plate, charpy impact-tested by American Bridge to 15 ft. lbs. @ −50°F. Then it was flame cut and roll formed. Its main stem was 100% radiographed, and its nozzle penetration was magnetic-particle inspected. The entire vessel was then stress relieved at 1150°F. for four hours. And finally, it was placed on special flat cars for delivery. ☐ This kind of job demands the complete, modern, high-capacity facilities that permit our Orange, Texas plate shop to handle all kinds of custom plate work. High-capacity cranes, mammoth car bottom furnaces, giant presses and bending rolls, the latest in welding equipment, and complete inspection facilities. This plus know-how and strategic location permit us to produce all kinds of plate work efficiently and economically. And anything we make, we can erect. Write for our booklet on plate fabricating facilities and services.

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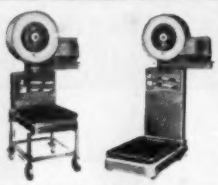
USS

TOLEDO SCALES that PRINT Complete Weight Records for You . . .

. . . *THE ANSWER* to prevent "guesswork" and errors in cost control!


BENCH SCALE

PORTABLE SCALE

FLOOR SCALE

Toledo Printweigh Scales are available in a wide range of models, including Portable, Floor, and Bench types as illustrated; also Built-in, Hopper, Overhead Track and Motor Truck types.

Human errors in reading, remembering and recording weights are eliminated with Toledo Printweigh "400" Scales. They're the surest way to satisfy your requirements for weight records that are complete and indisputable.

Weights are printed in full figures, even when unit weights are used. Choice of printing on 8½" x 11" forms, or on tickets; also on strips. Weight data may be transmitted electrically for recording on remote adding or other office machines. "Memory" feature available for printing weight data, even after load is removed.

Toledo Printweigh "400" Scales give new flexibility and efficiency in weighing . . . to cut costs, guard quality, prevent profit-stealing weighing errors. Ask your Toledo representative for the full story on Printweigh Scales, or WRITE TODAY FOR BULLETIN 2017. TOLEDO SCALE, Division of Toledo Scale Corporation, Toledo 12, Ohio
(Toledo Scale Co. of Canada, Ltd., Windsor, Ont.)

"MISFIT" SCALES MULTIPLY COSTS

Scales can become "misfits" as a result of changes in plant layout, materials handling, inventory controls, value or quantity of materials weighed. If this has happened in your plant, the results can be costly. For example: weighing errors, production bottlenecks, materials handling inefficiencies. Be sure your scales are adequate for the job. Ask your Toledo representative about a scale adequacy check in your plant, or send for the Toledo Weight Fact Kit.

SERVICE

TOLEDO® *Headquarters for Weighing Systems*

LITERATURE . . .

Valves, Solenoid.....Catalog Manual No. 108 describes valve construction & other general information as well as a Chemical Selection List & Valve Selection Charts.
182A Valcor Engineering Corp.

Valve, Swing Check.....Fig. 2433SS large stainless steel for 150 W.P. Bolted flanged cap. Integral seat. Teflon disc & renewable seat ring available on special order. Lit.
125b *The Wm Powell Co.

Valve, Tank.....Fig. 2309 large flush bottom tank valve for 150 W.P. Designed for fast draining. Disc opens into tank. Also available with disc opening into valve.
125c *The Wm. Powell Co.

Valve, "Y".....Fig. 2107 small stainless steel for 150 W.P. Flanged ends, but can be supplied with screwed or socket welding ends. Literature available.
125d *The Wm. Powell Co.

Valves.....with teflon coated plugs are now available for use where infrequent or inadequate plug valve lubrication might be expected. New booklet on coated valves.
145 *Rockwell Mfg. Co.

Valves, Diaphram.....give smooth passage of material . . . eliminate trapping of solids, reduce frictional resistance. Information on how they can help your installation.
89 *Grinnell Co.

Valves, Emergency Relief.....provide emergency relief capacity beyond that furnished by operating vent. Weatherhood protects entire valve. Information in "Blue Book."
186b *The Protectoseal Co.

Valves, Gate.....for high-pressure corrosive service. Information on Aloyco valves for your specific corrosive service contained in Bulletin #7.
156 *Alloy Steel Products Co.

Valves, Gate.....Information on these rubber lined valves & data on other gate valves including the range of alloys, types & constructions for ordinary or special service.
148 *Darling Valve & Mfg. Co.

Process Equipment

Attrition Mill.....Complete details on the full line of single runner attrition mills covered in Bulletin 143 which is now available to you on request.
144b. *Sprout, Waldron & Co., Inc.

Centrifugal.....The Batch-O-Matic handles greater out-of-balance loads with minimum vibration because of its low, compact design & center-slung suspension. Bul.
176 *American Machine & Metals, Inc.

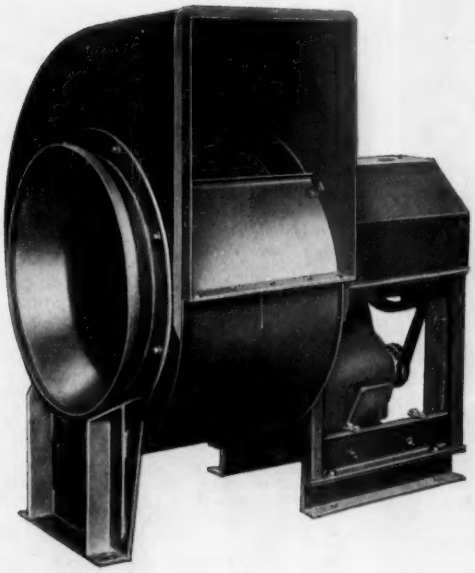
Centrifugal.....The HS 40 W Universal Pressure Centrifugal is engineered for normal operation at 1000 times gravity & internal pressures to 150 psi. Specifications.
55 *Baker Perkins

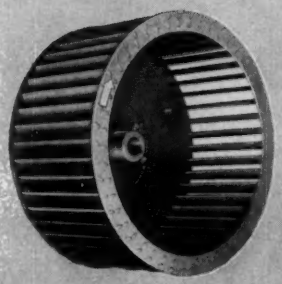
Centrifuge.....The new SRG-214 Hermetic centrifuge is capable of operating at pressures up to 123 psi (and higher where necessary). Capacities up to 5,000 gals. per hr.
6-7b *The De Laval Separator Co.

* From advertisement, this issue.

CLARAGE

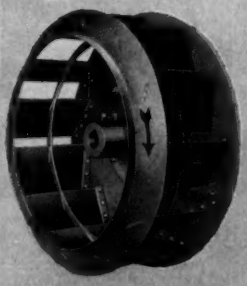
New line of
V-belt driven
Ready Units





LS Ready Units have Low Speed, forward curved blade wheels. These are of the long-recognized Clarage Type HV multiblade design.

or



MS Ready Units have Medium Speed, backward inclined blade wheels with non-overloading horsepower characteristic. These are of the highly regarded Clarage Type NH, Class I design.

Exceptionally sturdy, quiet, ready-to-run fan sets

- for volumes up to 25,000 CFM
- for static pressures thru 2½"
- for clean air up to 300° F.

Distinguishing points — over 15 of them — make these new Clarage units outstanding.
To mention a few: Better motor ventilation . . . entire drive within frame of unit . . . complete accessibility to motor, drive, and bearings. Learn more about the numerous specific advantages that mean greater value to you from Clarage. Request Catalog 517 . . . 36 pages of complete information, selector charts, capacity tables, dimensions. Clarage Ready Units are ideally suited for supply or exhaust jobs — indoors or outdoors — for buildings of all types, all sizes.

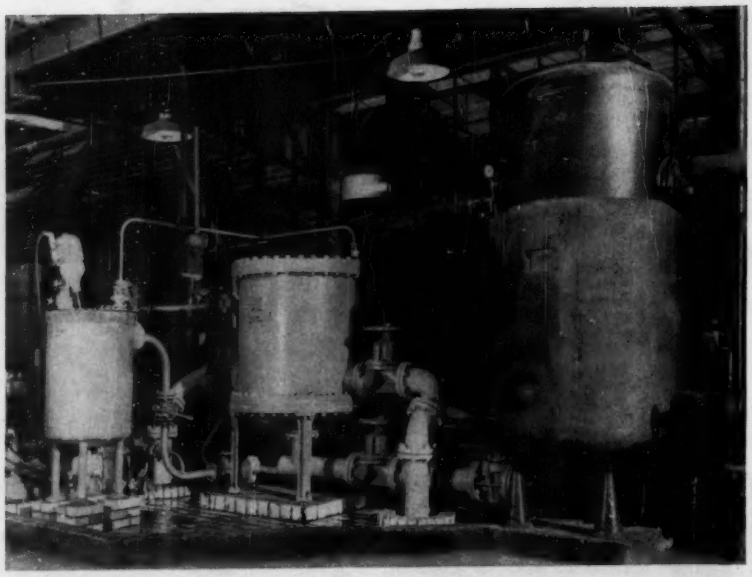
Write for your Copy

Dependable equipment for making air your servant

CLARAGE FAN COMPANY

Kalamazoo, Michigan

SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., 4285 Richelieu St., Montreal



This Adams plant, operating at Rohm & Haas since 1956, embodies all of the features necessary for safe and labor-saving filtration.

HAZARD FREE FILTRATION

...WITH MINIMUM OPERATING LABOR

with Adams Chemical Filters

A totally enclosed system . . . rapid backwashing without disassembly . . . corrosion resistant construction plus chemically inert filter elements . . . provide maximum safety and economy in Adams Chemical Filters, particularly where highly toxic and corrosive liquids are handled. There is no human contact with the material being filtered either during filtering — or backwash cleaning.

The mixing tank provides continuous filter air feed for a maximum filter cycle. The Adams Filter Unit, with its permanent Poro-Stone element, delivers crystal-clear filtrate with negligible attention and without other interruption than backwashing. The storage tank contains backwash liquid under pressure. Opening the storage tank valve and reversing the flow in the filter unit by quick-acting valves provides dynamic backwashing. You get complete purging action of the filter cake and pores of the filter tube in only 30 seconds. The filter is then put back on-stream with practically no interruption to the flow or loss of filtrate. There is nothing to disassemble, no gasketed joints to break. For continuous flow, many plants employ a second filter unit which is kept on-stream during backwashing of the first unit. Adams automated filtration equipment is available to reduce labor costs still further.

In all Adams plants, the totally enclosed system . . . the chemically inert construction . . . the continuous filter aid feed . . . and the backwash cleaning by valve control . . . combine to provide the ultimate in safety and economy for chemical process filtration.

Your request for Bulletin 431, containing complete details on this safe, economical filtration, will be promptly answered.

R. P. ADAMS CO., INC. 207 EAST PARK DRIVE BUFFALO 17, NEW YORK

LITERATURE . . .

Centrifuge.....The Super Conejector fills an important spot in slurry processing & in many dewatering applications. It offers unexcelled efficiency. Literature.
135 *The Sharples Corp.

Centrifuges & Homogenizers.....Catalog shows refrigerated and non-refrigerated models as well as vacuum and non-vacuum centrifuges. Details given on rotors.
184A Lourdes Instrument Corp.

Compacting process.....is a simplified continuous operation. Uniform size granules produced by this process flow freely, have controlled solubility. Information.
67 *Allis-Chalmers

Conical Vaccum Dryer.....is available in 2½ to 233 cu. ft. capacities & equipped with condenser, hot-water heating system, pipe, vacuum pump & controls. Details.
71 *J. P. Devine Mfg. Co

Crusher.....New "Atlas" crusher is a compact, powerful, single-roll machine that fits well into production lines. Can be started or stopped at any time. Bul. 2025.
157 *Pennsylvania Crusher

Crystallization Equipment.....with controlled crystallization. Bulletin No. 50A describes the principles & applications of Krystal crystallization equipment.
63 *Struthers Wells Corp.

Demineralizers.....are available in mono-column, dual-column and multicolumn types . . . in flow rates from 10 to 10,000 G.P.H. Full catalog information is offered.
L191 *Penfield Mfg. Co., Inc.

Dryer.....Modern, streamlined, with complete recording & control instrumentation, with every known safety device for protection of material & personnel.
174 *C. G. Sargent's Sons Corp.

Dryers.....Oriad Desiccant dryers offer complete reactivation, perfect temperature control, and full automatic operation. Further details in Bulletin D-103.
88 *The C. M. Kemp Mfg. Co.

Dust Control.....Bulletin discusses four main types of dust control products: dry centrifugals, wet and fabric collectors and electrostatic precipitators.
184B American Air Filter Co.

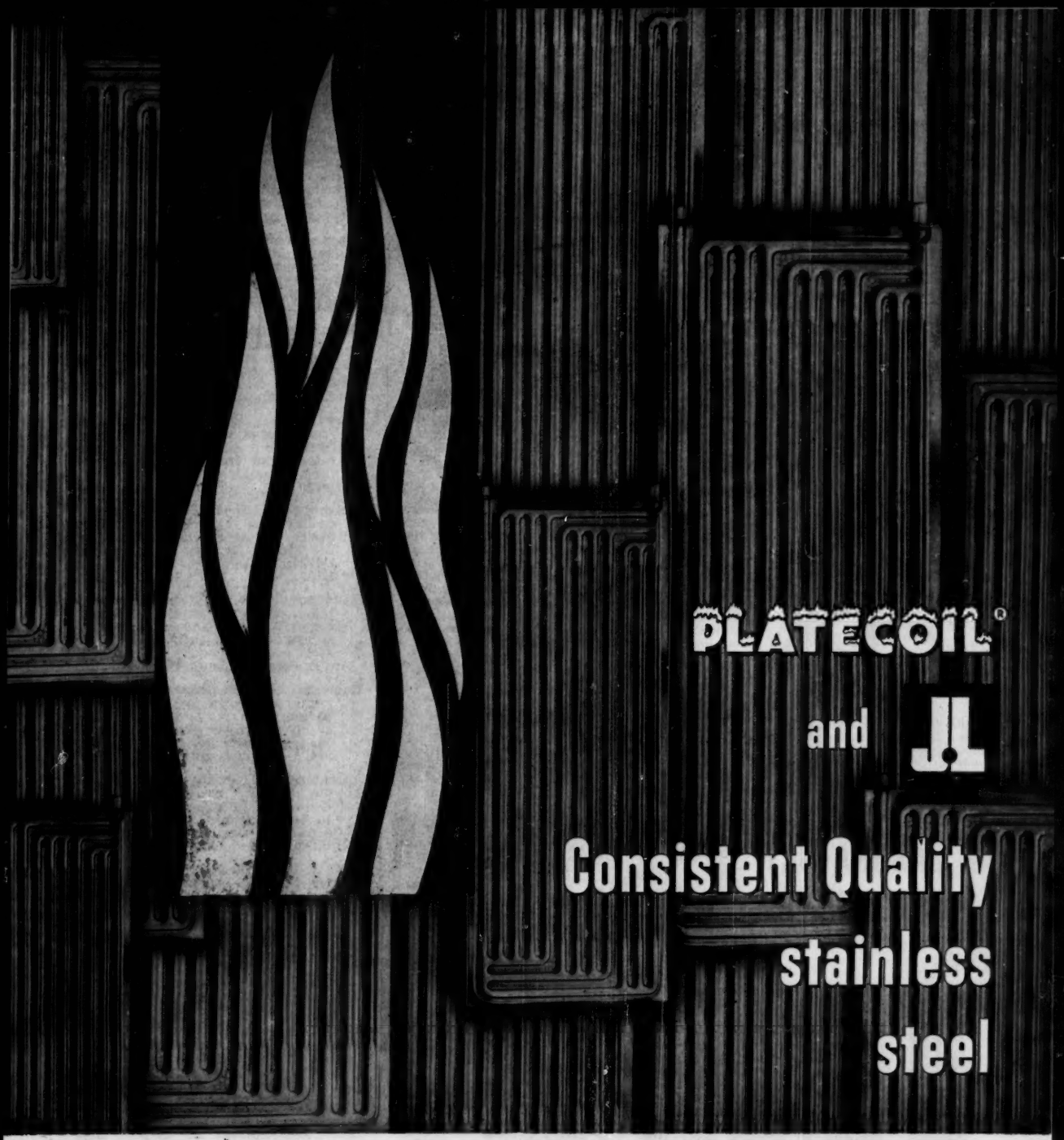
Filter.....Automatic Backwash Sand type in combination with flocculation & sedimentation equipment provides an uninterrupted supply of treated & filtered water. Bul.
168 *Hardinge Co., Inc.

Filter.....New automatic filter, Model HRC has horizontal plate cake stability plus automatic cake discharge. Precoating & cleaning can be fully automated.
155 *Sparkler Mfg. Co.

Filter Leaves.....“Rim-Lok” and other multi-leaves for pressure filters; standard leaves for stationary and rotary filters. Additional information in Catalog 57.
L190c *Multi-Metal Wire Cloth Co., Inc.

Filter Press.....can be equipped with any type of plates-made of virtually any material-to handle any filterable mixtures-and most filter media. Sperry Catalog offered.
81 *D. R. Sperry & Co.

* From advertisement, this issue.



Maintaining a constant temperature of 70 to 72° F in a 16⅔% sulfuric acid solution is an ideal application for Platecoil... typical of many engineered by Tranter Manufacturing inc., Lansing, Michigan.

Corrosive environments dictate the use of stainless steel, Tranter's rigid production requirements dictate the use of J&L Consistent Quality stainless steel.

Why J&L? Here's the reason given by Mr. M. C. Nolen, Tranter Purchasing Agent:

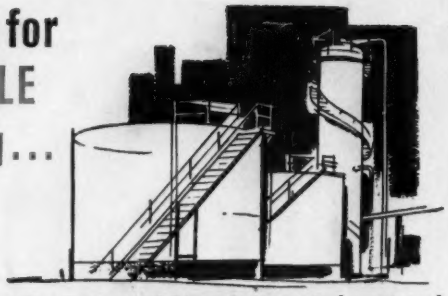
"Tranter uses J&L stainless because of its uniform quality. It takes all the headaches out of raw materials and makes our job a matter of just processing this superior product."

Plants and Service Centers:
Los Angeles • Kenilworth (N. J.) • Youngstown • Louisville (Ohio) • Indianapolis • Detroit

J&L STAINLESS
SHEET • STRIP • BAR • WIRE

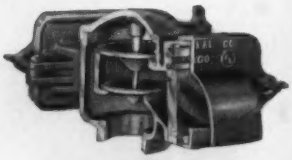
Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • DETROIT 34

PROTECTOSEAL for SAFE FLAMMABLE LIQUID Handling... Tank Storage, Processing, Testing, Research



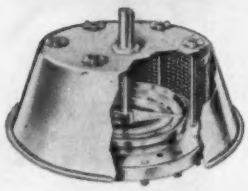
The Protectoseal Line of storage tank vents and fittings includes operating, emergency, and special purpose equipment to meet virtually any requirement of fire prevention and vapor control. In providing proper fire and explosion protection for over 35 years Protectoseal Engineers always consider the operating and maintenance problems of corrosion, sublimation, valve pressures, conservation, cleaning of flame arresters, or other situations peculiar to a given installation.

Two widely used units are illustrated here under the following headings:



CONSERVATION VENTS

Designed with flame arrester structure *outside* the vent housing. Advantages: (1) In event of ignition, vent burns at flame arrester—not the valves. Prevents warping and malfunction; (2) Flame arrester plates not continuously exposed to possible corrosive vapors; (3) Flame arrester structure keeps dirt and other foreign matter away from valves which might cause improper valve seating; (4) Self-draining of condensate. Protectoseal conservation Vents are UL and FM approved, and are made in a wide range of sizes.



EMERGENCY RELIEF VALVES

Provide emergency relief capacity beyond that furnished by operating vent. Free-lifting, self-closing valve is designed to relieve at 1 ounce/sq. in. settings up to 10 ounces/sq. in. can be provided. Metal-to-metal seat; non-metallic seat available. Coarse mesh screen prevents entry of foreign matter. Weatherhood protects entire valve. Emergency equipment available in complete range of sizes to 20½ inches.

Write for Protectoseal "Blue Book" — a complete and informative reference guide to storage tank equipment selection, design, and operation.

LABORATORY EQUIPMENT

OVAL SHAPE SAFETY STORAGE AND DISPENSING CANS — require less shelf space, permit storage of five containers in space normally required for three round cans. Flame arrester protection at all openings. Convenient handles, automatic pressure relief, liquid tight seals, available in stainless steel, Terne Plate.

SAFETY TILT CAN ASSEMBLIES — easily tilted for accurate, dripless dispensing from self-closing faucet. Can returns to vertical position when released. Flame arresters at all openings. Also available for wall mounting.

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177 *American Machine & Metals, Inc.

Filters, Chemical.....with totally enclosed system, chemically inert construction, continuous filter aid feed, & backwash cleaning by valve control. Bul. 431.
184 *R. P. Adams Co., Inc.

Filters, Continuous Vacuum & Pressure.....FEinc custom designs every filter for a specific application. Standard sizes range from 5 to 800 sq. ft. of filtering area. Bulletin.
178 *American Machine & Metals, Inc.

Filters Pan.....Bulletin defines the area of application of tilting pan filters, used for handling a broad category of free-flowing, fast-settling materials.
186A The Eimco Corp.

Gas and Liquid Drying.....The Molecu-Dryer for your many new drying needs. A comprehensive picture of the Molecu-Dryer is contained in Bulletin 5703.
R164 *C. I. Hayes, Inc.

Hammermills.....Illustrations and photo views of various crushing elements, components, parts and accessories given in bulletin.
186B
Gruendler Crusher & Pulverizer Co.

Homogenizers & Dispersers.....reduce ingredients down to their ultimate particle size . . . disperse them evenly. Give you control of particle size & viscosity. Bulletins.
204 *Manton-Gaulin Mfg. Co., Inc.

Micronizers.....grind & classify in one operation in a single chamber & provide fines in range from ½ to 44 microns. Eight models are available. Description in Bul. 091.
R190 *Sturtevant Mill Co.

Mixers.....A 32-page bulletin covers the Series E Lightnin Mixers with 1 to 500 h.p. Includes features, mechanical details and applications of these mixers. B-102.
206 *Mixing Equipment Co.

Mixers.....A full line of side drive, tank top, portable or tripod and continuous pipeline mixers for your mixing needs. Additional information in Bulletin 582.
65 *Nettco Corporation

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36 *Philadelphia Gear Corp.

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186C Gump Co.

Processing Equipment.....Votator is used for continuous polymerization reactions in numerous installations. Packaged Votator pilot systems are now available. Details.
59 *Girdler Process Equip. Div.

Spray Drying Nozzle.....The SDX nozzle is available in a full range of flow rates, each rate furnished as standard in several spray angles. Spray Drying Catalog.
L164 *Delavan Mfg. Co.

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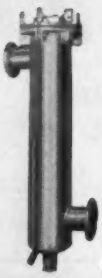

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180 *Spray Engineering Co.

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L190d *Multi-Metal Wire Cloth Co. Inc.

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8-9 *F. J. Stokes Corp.

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69 *Allis-Chalmers

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6-7c *The De Laval Separator Co.

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86 *Aldrich Pump Co.

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B202 *Blackmer Pump Co.

Pumps.....The new Bilton model is available in capacities from 10 to 2,000 gpm, heads to 520 ft., motors from ½ to 60 hp. Additional information in Bul. #3-1004.
45 *Byron Jackson Pumps, Inc.

Pumps.....A complete line of Pulsafeeder pumps with metered flow rates from a few drops to 15.7 gal. per minute; pressures up to 7000 psig. New Catalog 59.
35 *Lapp Insulator Co., Inc.

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205 *A. R. Wilfley & Sons, Inc.

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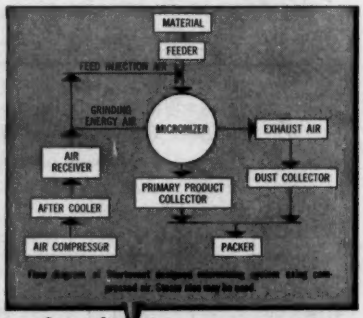

One Operation Reduces, Classifies

Sturtevant Micronizers grind and classify in one operation in a single chamber—provide fines in range from ½ to 44 microns to meet today's increased product fineness needs. Can handle heat-sensitive materials.

Production Model (15 in. chamber)

No Attritional Heat

Particles in high speed rotation, propelled by compressed air entering shallow chamber at angles to periphery, grind each other by violent impact. Design gives instant accessibility, easy cleaning. No moving parts.

Classifying is Simultaneous

Centrifugal force keeps oversize material in grinding zone, cyclone action in central section of chamber classifies and collects fines for bagging. Rate of feed and pressure control particle size.

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Grinding chambers range from 2 in. diameter laboratory size (½ to 1 lb. per hr. capacity) to large 36 in. diameter production size (500 to 4000 lbs. per hr. capacity). For full description, request Bulletin No. 091.

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Sturtevant will help you plan a Fluid-Jet system for your ultra-fine grinding and classifying requirements. Write today.

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*REGISTERED TRADEMARK OF STURTEVANT MILL CO.

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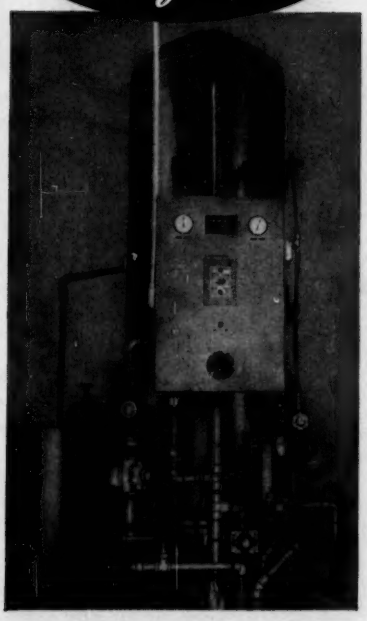
Check the pioneer maker* of "Packaged" Demineralizers

Penfield



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171 *Lawrence Pumps Inc

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186a *The Protectoseal Co.

Conversion Table & Circular Slide Rule.....now offered, for chemical engineers, is shirt-pocket size. Includes slide rule, table of elements, etc.
79-80i *U. S. Industrial Chemical Co.

Drum Faucets, Stainless Steel..... are available for ¾" NPT opening. Self positioning . . . may be screwed into drum bung opening & spout swivels to dispensing position.
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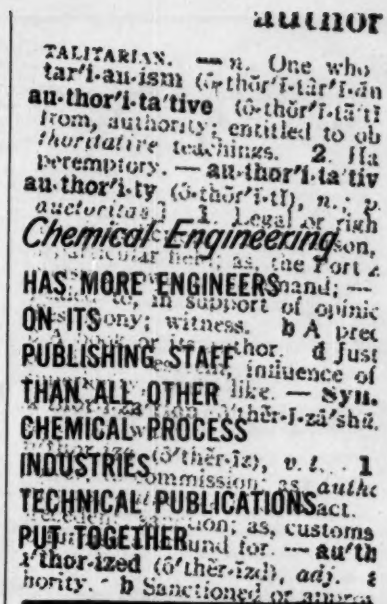

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Dryer: American atmospheric, 24 x 48".
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Filter: Oliver precoat 12 x 2" st. steel.
Filter: Eimco st. st. drum 16" x 12".
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1—Falls Industries, 100 sq. ft. Karbate Condensor.
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1—Baker Perkins 5'6" x 6' Rotary Vacuum Dryer.
2—Buflovak 5' x 30', 3' x 7'6" Rotary Vacuum Dryers 316 S.S.
2—Louisville Rotary Steam Tube 6' x25', 6' x 50'.
2—Louisville 8' x 50' Stainless Steel lined Rotary Dryers.
9—Rotary Dryers 34" x 30', 4' x 40', 6' x 50', 6' x 60', 7' x 80', 8' x 87'.
1—Traylor 30" x 18' Stainless Steel Rotary Dryer.
2—Link Belt, 7'5" x 25', 6'4" x 24", S.S. Louvre Dryers.
2—Atmos. Tray Dryers, 16 shelves, 40" x 24".
1—P&S 10' wide Apron Conveyor Dryer 48' long.
1—4' dia. 304 S.S. Spray Dryer.
2—10' and 4' dia. 304 S.S. Spray Dryers.

MIXERS

1—Farrel-Birmingham "Midget" Banbury Mixer.
2—Day Imperial 150 gal. jktd. double arm.
1—Baker Perkins 100-gal., jacketed, double arm, 30 HP.
1—Baker Perkins #16TRM, 150 gal. jktd., Vac. 60 HP.
1—Baker Perkins 50 gal. jacketed, double arm.
1—Baker Perkins 10 gal. jacketed 304 S.S. double arm.
5—Day "Cincinnatus" double arm, 250 and 100 gal.
2—Steel jacketed Powder Mixers, 225 and 350 cu. ft.
1—Patterson 6' dia. Conical Blender 15 HP.
1—3' dia. Simpson Intensive Mixer.
1—Stokes 21K, 304 S.S. Granulating Mixer 82 gals.

MISCELLANEOUS

1—Farrel Birmingham 8" x 16", 2 Roll Chrome Plated Mill.
4—Mikro Pulverizers 1 #4TH, 1 SH, 1 SI and Bantam.
3—Abbe 2½' x 3' porcelain lined Pebble Mill XP motor.
1—Raymond 10" vert. Mill, 10 HP.
1—No. 1 Ball & Jewell Rotary Cutter.
1—#18 Cumberland Rotary Cutter.
3—Swenson Walker Continuous Crystallizers, 24" x 30' sections.
1—#24 Rotex Sifter, 20" x 64", Quadruple deck.
5—Day Roball Sifters 40" x 120" single and double deck.
1—#81 Day Roball Sifter 40" x 120" single deck.
3—Nash H6 Vacuum Pumps.
25—Chlorimet, Durimet and Duriron Centrifugal Pumps 1½" to 6".
5—Day Roball Sifters, 40" x 120", 40" x 84", Double Deck.

Partial List of Values — Send for Complete Circular

TEXAS OFFICE: 4101 San Jacinto St., Houston 4, Texas—Tel.: JAckson 6-1351

BRILL EQUIPMENT COMPANY
35-61 JABEZ ST., NEWARK 5, N. J. Tel.: MArket 3-7420

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SAVE ON EQUIPMENT STILL ON LOCATION

J. H. Day 150 Gal. Jacketed Mogul Double Arm Mixer Sigma Blades; Vacuum Cover; 75 HP
Bailey 60"x180" Ribbon Mixer with 50 HP Motor, with 50 H.P. Motor
Blaw Knox Dbl. Cone Blender; 9'6" Diameter
Patterson-Kelley 150 cu. ft. Twin Shell S/S Blender
6 Stokes 150 Ton Self Contained Moulding Presses with Pumping Systems and Controls
2 Ball & Jewell No. 2 Rotary Cutters; 50 HP.
2 Sturtevant Stainless 30" Micronizers, accessories
500 Gal. Stainless Reactors; 5'x5' Bolted Heads. Rake Type Agitators; Dorrco made
Durimet Centrifugal Pumps; 6"x4"; 40 H.P. Motors
Link Belt Roto Louvre Dryer; Model 502-20, comp.
Komarek Greaves Briquetting Presses, 160,000 lbs. per sq. in.
Birmingham-Farrell UNUSED 2 Roll Mills, 14"x30"

REACTORS AND PRESSURE VESSELS

Nickel Clad Reactor; 7' x 11'6"; Manhole; Jacketed and Agitated.
Lancaster Stainless Lined Rotary Reactor; 50' x 17'4"; Jktd.; 300 PSI.
Mojonnier S.S. Vacuum Pans; 3' x 10'; 6' x 12'.
3 Stainless Steel Vertical Pressure Vessels 42" x 10'; Dished Heads.
2 MONEL REACTORS; 2800 Gal. 6'8" x 13'; 175# ASME Jktd. & Internal.
Struthers Wells Stainless Drum Dryers; 5' x 10' and 5' x 4' Complete.
Sparkler S.S. Lithcote Lined Filter; 500 sq. ft.
Ames 300 HP Automatic Boiler; ASME 1956; No. 6 Oil Fired.
Struthers Wells Type 316 Stainless Steel Jktd. & Agt. Reactors 2000 Gal.
Stainless Steel Heavy Duty Pressure Tanks; 850 Gal. with Agitators.
9 Devine Vacuum Chamber Dryers from Lab. Size to No. 36 Double Door.

DRYERS AND EVAPORATORS

Stainless Lined Rotary Dryer; 50" x 20'; Stokes Rot. Jktd. 34" x 10'.
Double Drum Dryers by Buffalo & other makers 28" x 60" to 40" x 120".
Zaremba Double Effect INCONEL Evaporator with Calandria; 430 sq. ft.
Stainless Lined Rotary Counter Current Atoms. Dryer 50" x 20'.
Pittsburgh Lectro Dryers; Models BAC Size 25; BWC Size 3500.
Bowen Stainless Lab. Spray Dryer; 30" x 32".
Multi Pass Jacketed 12" Screw Conveyor; 4 Sections 10' S/S Troughs.

FILTERS AND FILTER PRESSES

Shriver and Sperry Filter Presses to 42" Cast Iron, Stainless, Ni-Resist, Aluminum.
Oliver Continuous Rotary Panel Type Vacuum Filters; 8' x 8' and 8' x 10'.
Feinc String Type Rotary Vacuum Filters 3' x 1', 6' x 6' & 8' x 10'; Stainless contacts.
Bird Young Rotary Vacuum Filter, 4' x 4'. Sweetland Pressure Filters No. 2 to 12.
Enzinger Vertical Stainless Pressure Filter; 18" x 26"; ASME; 24 sq. ft.
Stainless Nutsche Type Filter 5' dia. x 2'. Bowser Filter w/Pump; 2000 GHP; 69 sq. ft.

MILLS—GRINDERS—PULVERIZERS

Abbe Jacketed Steel Ball Mills, 42" x 36" with charge of balls.
International Porcelain Lined, Ball Mill 8' x 8'; 50 HP Motor.
Patterson Jacketed Ball Mill, 54" x 42"; good for Vacuum.
Mikro Pulverizers; up to No. 4's. Mikro SS Atomizers Model 5 & 6.
Fitzpatrick Comminuting Mills, S.S.; Models C, D, E.
Williams Hammer Mills to 16" x 48". Raymond Imp Mills; many models.
Williams Ring Roll Lab Mills, 3 Roll. 10" x 3"; complete.
American Ring Roll Crusher with 30" x 33" Throat 50 HP Motor.

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FMC

CIRCLE P ON READER SERVICE CARD

LIQUIDATION
ALCOHOL PLANT
OMAHA, NEBRASKA

MAJOR ITEMS

5—Buflovak 42" x 120" dbl. drum dryers, ASME 160#
2—Bonnet 7' x 60' rotary dryers, 5/8" shell
1—Bonnet 6' x 52' rotary dryer, 5/16" shell
6—Davenport #2A dewatering presses
3—Davenport #1A dewatering presses
2—French Oil screw extrac. presses, 300 PSI
2—Sweetland #12 pressure filters, 336 sq. ft.
6—Shriver 48" Cast Iron P. & F. filter presses, (50) chambers, hydraulic closure, closed deliv.
2—19,900 sq. ft. quadruple effect calandria type evaporators, copper tubes, cast iron bodies, with preheater & finishing pan
6—Ansonia 691 sq. ft. dbl. pipe coolers, copper tubes
3—American 654 sq. ft. spiral steel heat exchangers
18—Tubular heat exchangers, copper tubes: 1500, 1350, 1130, 637, 380, 290, 184, 176, 156 sq. ft.
1—ACME 96" dia. x 44' high copper beer still column, (20) perforated & (4) bubble cap trays
5—Leader Iron 96" dia. steel rectifying columns, 44' & 51' high, bubble cap trays
2—9500 gal. horiz. cookers, 9' dia. x 20' long, 1/2" shell & dished heads, agits.
4—Wallace & Tiernan auto. bulk handling scales
6—Forster #8 hammermills, 100 HP
4—Forster #6 hammermills, 75 HP
1—Stedman 36" dia. 3-row cage mill
1—Prater "Blue-Streak" pulverizer, 30 HP
2—Allis-Chalmers Inter-plane grinders, 100 HP
1—"Jay Bee" #4 hammermill, 75 HP
9—Davenport 5' x 25' inclined "slop" screens
250—Steel pumps, 1" to 12", 1 HP to 150 HP
100—Steel & stainless steel screw conveyors
5000 HP—TEFC motors, 3/60/220-440/, to 150 HP
20—Steam turbines, to 150 HP
200—Steel tanks & bins, all sizes
12—300 amp. portable welders, elec. & gasoline

SEND FOR CIRCULAR #960-A

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CIRCLE Q ON READER SERVICE CARD

AMERICA'S LARGEST STOCK

ROTARY DRYERS & KILNS

3—10′ x 78′ National rot. dryers, ¾″ shell with indirect heat center, tube, 200 HP drive, fan, etc.
1—10′ x 11′ x 175′ Vulcan Kiln, 13/16″ shell, 2-tire
2—8′-8″ x 70′ Hardinge #XA-18 dryers, ⅝″ welded
1—8′ x 60′ Davenport rotary dryers, $\frac{7}{16}$″ welded
1—8′ x 60′ Consol.-Western Kiln, ½″ welded shell
3—8′ x 40′ Stearns-Roger dryers, ½″ shell
1—7′-6″ x 62′ rotary kiln, ½″ welded
1—7′ x 70′ Louisville rotary cooler, ½″ welded
2—7′ x 60′ Bonnet rotary dryers, ⅝″ shell
1—7′ x 50′ Allis-Chalmers dryer, ⅝″ shell
1—6′ x 7′ x 100′ rotary Kiln, ½″ shell, 2-tire
2—6′ x 52′ Bonnet rotary dryers, $\frac{5}{16}$″ shell
1—6′ x 50′ Louisville rot. steam-tube dryer
1—6′ x 25′ Louisville rot. steam-tube dryer
1—6′-4″ x 18′ Link-Belt #604-18 Roto-Louvre
1—5′-6″ x 30′ rotary dryer, ⅜″ shell
2—4′-9″ x 32′ rotary dryers, ⅜″ shell
1—4′-6″ x 40′ Ruggles-Coles rotary dryer
1—4′ x 30′ Hardinge rot. steam-tube dryer
1—3′-10″ x 20′ Link-Belt #310-20 Roto-Louvre
1—3′ x 23′ Standard rotary dryer, ¼″ welded shell
1—3′ x 15′ Bartlett dryer, Everdur shell
1—3′ x 10′ rotary stainless steel dryer
2—2′ x 9′ rotary perf. shell dryers
1—1′ x 8′ rotary stainless steel dryer

SEND FOR "DRYER" CIRCULAR #860A

RECENT STOCK PURCHASES

1—4300 gal. T304 SS tank, 6′ x 20′, ASME 50# WP
3—300 HP Cleaver-Brooks PACKAGE Boilers, 150#
4—Buflovak 32″ x 100″ double drum dryers, chrome plated.
1—Stokes model #R single punch tablet press
2—#3TH Mikro Pulverizers, stirrup hammers
1—Raymond 50″, 5-roller hi-side mill
1—J. H. Day #8, 150 gal. sigma blade Cinc. mixer
2—J. H. Day #5, 75 gal. sigma blade Cinc. mixers
1—Buflovak 110 sq. ft. Vacuum shelf dryer
1—Buflovak 98 sq. ft. Vacuum shelf dryer
1—Patterson 6′ x 10′ pebble mill, porcelain lined.
1—Baker-Perkins #15-UUMM, 100 gal. dispersion blade jacketed mixer, cored blades, 100 HP XP drive, compression cover.
2—Hardinge 7′ x 36″ conical pebble mills
1—Bird 32″ x 50″ T316 SS horiz. cent.
1—A.T.&M. 12″ dia. susp. cent., T304 SS, perf.
1—Tolhurst 48″ dia. sus. cent., T304 SS, perf.
22—Sharples #AS-16V super centrifugals, sludge disch. frame, Inconel, 3 HP.

CLOSING OUT!

CHEMICAL PLANT—ORANGE, TEXAS

TYPE 316 STAINLESS STEEL EQUIP.

1—Struthers-Wells T316 SS 3500 gal. jkt. reactor, agit.
1—Struthers-Wells T316 SS 630 sq. ft. calandria type single-effect evap., 2″ OD T316 SS tubes
2—Sharples #C-20 Super-D-Hydrators, T316 SS
1—Sharples #16-P Super-cent., T304 SS
1—Vulcan 110″ dia. T316 SS bubble-cap scrubber column, 13′ high, 10 trays
1—Vulcan 96″ dia. T316 SS bubble-cap column, 37′ high, 30 trays
1—Vulcan 72″ dia. copper bubble-cap column, 46′-10″ high, 40 trays—VACUUM
1—Vulcan 60″ dia. T316 SS bubble-cap scrubber column, 13′ high, 10 trays
3—Worthington 160 ton steam-jet vacuum refrigeration units, with baro. cond., etc.
2—Read 1800 cu. ft. T304 SS weigh hoppers, on scales, with shaker-conveyors, etc.
2—Bucket elevators, T304 SS, 5″ x 3¾″ T304 SS buckets on T304 SS chain: 60′, 41′ high c/c
2—18,000 gal. Aluminum tanks; 12′ dia. x 31′ OAH
2—American T316 SS blowers, 5600 cfm, 50 HP
2—Buffalo T316 SS blowers, 2330 cfm, 60 HP
1—1200 gal. horiz. steel still kettle, 5′ x 8′, ⅝″ shell & dished heads, 320 sq. ft. int. coil
1—1960 sq. ft. T316 SS heat exchanger, 1″ OD tubes
2—1450 sq. ft. T316 SS heat exchangers, 1″ OD tubes
6—1400 sq. ft. T316 SS heat exchangers, 2″ OD tubes
5—800 sq. ft. T316 SS heat exchangers, ⅝″ OD tubes
1—800 sq. ft. T316 SS heat exchanger, 1″ OD tubes
1—730 sq. ft. T316 SS heat exchanger, 1″ OD tubes
19—T316 SS tubular heat exchangers: 510, 427, 410, 400, 390, 290, 277, 264, 250, 125, 54, 52, 50, 47 sq. ft.
1—Otis 5000# cap. elec. frt. elevator, 40′ lift
4—Ing.-Rand #5HC, 6″ x 5″ T316 SS cent. pumps
3—LaBour self-priming T316 SS pumps; #15, 10

TYPE 316 STAINLESS STEEL TANKS

3—2750 gal. vert., 7′ x 8′, ¼″ shell & dished heads.
2—2300 gal. vert., 7′ x 8′, ¼″ shell, $\frac{7}{16}$″ dished top, ⅝″ at bottom. Paddle agit., 60 sq. ft. coil.
4—2250 gal. vert., 7′ x 6′-3″, vert., dished heads.
1—2100 gal. vert., 6′ x 9′-10″, open top, cone bottom.
1—1900 gal. vert., 6′ x 8′, ⅜″ shell & dished heads—VACUUM.
6—685 gal. vert., 3′ x 13′, 120 sq. ft., int. coil.
15—100 gal. separator tanks, cone bottoms, 20# WP.
30—T316 SS tanks, 18 to 200 gal.

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TYPE 316 STAINLESS STEEL EQUIPMENT

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1—2600 gals. type 316 SS vertical vacuum receiver
4—Vert. type 316 SS activated carbon absorbers, 5'4" dia. x 16'
1—Struthers Wells 75 gal. type 316 SS, 500# pressure vessel, ASME code National Board
2—Aluminum horizontal 5000 gal. storage tanks
2—Rubber lined horiz. storage tanks, 5500 gals. working pressure 45#
6—Rubber lined vertical storage tanks, 4500 gals. working pressure 45#
2—Rubber lined vertical storage tanks 2500 gals. working pressure 45#
4—Type 316 SS packed columns, 18" x 11' 7⅛", working pressure 45#
2—Buflovak type 316 SS jacketed rotary vacuum dryers, 5' x 30', complete with 25 HP explosion proof motors and drives
3—Type 316 SS Ter-Meer continuous type centrifuges, 4' dia. bowls, complete with motors
3—Readco stainless steel horizontal blenders, 450 cu. ft., working capacity, complete with 75 HP motors.
3—Mikro Model 3TH stainless steel pulverizers, complete with 40 HP explosion proof motors.
3—Nash Model TS-12, vacuum pumps, with motors
5—American type 316 SS blowers, Model MD, size 27"
1—Fuller type 316 SS, airveying system
1—Aldrich Groff type 316 SS hydraulic triplex pumps, size 2¾" x 4" at 500 psi
100—Stainless steel centrifugal pumps, all makes and sizes
2—Powell type 316 SS, 10" hyd. oper., flanged and gate valves
2—Tyler type 38 tandem SS Hum - - mer screens, size 42" x 9'8"
3—Williams type 316 SS hammermills with 100 HP motors
3—200 gals. type 316 SS jacketed kettles
500 Tons of type 316 SS pipe, fittings, and valves, from 2" to 8"
500 tons of structural steel.
50—Stainless steel and aluminum hoppers, all sizes.

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CIRCLE S ON READER SERVICE CARD

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74 CFM 1500 PSI 6¼-3¾-1⅝x7 CP. TCB3
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110 CFM 3000 PSI Ing. GC 50BW
138 CFM 100 PSI 7x7, Ing. ES, CP & Joy
288 CFM 100 PSI 9x9 Ing. Worth. CP
311 CFM 1500 PSI 10½-7⅛-3½x13 IR-ES3
331 CFM 350 PSI 11-5x11 CP TCB-2
364 CFM 100 PSI 10x9 Joy WG 9
465 CFM 100 PSI 12x11-IR-ES CP.T. Worth HB
502 CFM 125 PSI 12x13 Worth HB
660 CFM 125 PSI 11¼-7x7 Joy Wn 102
676 CFM 125 PSI 15-9¼x12 IR XCB
686 CFM 100 PSI 14x13 Ing. ES
877 CFM 125 PSI 17-10½x14 IR. XRB
1050 CFM 60 PSI 13-13x12 IR-XRE
1058 CFM 110 PSI 18-11x12 CP-OCE
1665 CFM (actual) 100 PSI C300-300H Fuller

AMERICAN AIR COMPRESSOR CORP.
Chem. Road, North Bergen, N.J. UNion 5-1397

CIRCLE T ON READER SERVICE CARD

BARGAINS GALORE!

2—30" S.S. Bubble Cap Columns.
5—Rotex Screens 30" x 96"; 40" x 84"; 60" x 84".
1—Day 50 Gal. S.S. Sigma Blade Mixer.
1—Jeffrey Traylor S.S. Screen 30" x 62".
3—Spiral Blenders 1000# to 3000# Capacity.
1—Raymond 36" Whizzer Separator.
1—Rotocione Size 16, Type W.
1—Sturtevant 2" x 6" Open Dr. Lab. Crusher 5H.P.
1—Patterson 8' x 6' Jack. Ball Mill 20 H.P.
1—Abbe 50 Gal. Porc. Lined Mill, M.D.
1—Autoclave 1000 psi, 30 Gals., S.S.
1—Cyclotherm Boiler 620# hr., @250 psi.
5—Hercules Type 316 S.S. Filters, 8" & 16" square.
Conveyors, Labelers, Agitators, etc.

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CIRCLE V ON READER SERVICE CARD

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Model #705-24, 7'-5" O.D. x 24' long. Complete w/6,000,000 BTU per hour gas burner air supply w/motor & blower & Clarage fan for heater air supply.

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CIRCLE W ON READER SERVICE CARD

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Allis-Chalmers 6' x 50' Rotary S S Lined Dryer. ½" shell

6' x 20' Rotary brick lined Kiln. Welded Shell. Complete

Symons 2' Standard Cone Crusher. 30 HP Motor. Extra new parts

Patterson-Kelly 1 cu. ft. Twin Shell Blender. Bronze. ½ HP Mtr

St Regis 3 Spout Valve Packer. Model 107 FC. 25 HP Motor

Bird 40" x 60" S S Horiz. Cont. Centrifuge. 50 HP Motor

Hardinge 25' Double Rake Thickener Mechanism. ¾ HP

A T & M 42" S S perf. basket Centrifuge, plow & bot dump 25 HP

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CIRCLE U ON READER SERVICE CARD

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CHEMICAL PROCESS EQUIPMENT

2—American 42" x 120" double drum dryers, ASME, N.B., complete with drives and motors
1—Buflovak twin drum, chrome dryer, 32" x 90", complete
3—Pfaudler stainless steel jacketed reactors, complete with impeller type agitators and drives, 3, 5, and 10 gals.
1—Pfaudler glass lined jacketed reactor, 100 gals., complete with impeller type agitator and drive.

AUTOCLAVES, KETTLES AND REACTORS

2—Pfaudler glass lined 50 gal. jacketed reactors complete with anchor type agitators and drives
1—Pfaudler glass lined 100 gal. jacketed reactor complete with anchor type agitator and drive
2—Monel 2500 gal. jacketed autoclaves, 175# jacket, 175# internal pressure
1—Struthers Wells type 316 SS jacketed reactor, 2000 gal., complete with agitator and drive
2—2500 gal. stainless steel open top jacketed kettles
1—Van Alst 250 gal. SS jacketed kettle, complete with SS column and condenser
2—Blaw-Knox 600 gal. steel reactors, complete with double motion agitators and drives, 50# jacket, 50# internal

DRYERS

1—Allis Chalmers SS 6' x 50' rotary dryer, complete
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'
3—Link Belt steel roto louver dryers, Model 207-10, 310-16, 604-20
1—Stokes Model 59DS steel rotary vacuum dryer, 5' x 30'
2—Hersey SS rotary dryers, 3' x 16' and 18" x 11'6"
1—Buflovak SS jacketed rotary vacuum dryers, 3' x 15'
3—Buflovak steel jacketed rotary dryers, 3' x 15', 5' x 20', 5' x 35'
1—Traylor 4' x 40' rotary dryer
1—Western Precipitation Corp. S.S. pilot plant spray dryer, Type N-2
1—Bowen SS pilot plant spray dryer

FILTERS

3—Dorrco rubber covered filters, 6' x 2'
12—Sweetland #12 filters with 72 SS leaves
1—Niagara SS filter, Model 510-28
1—Oliver type 316 SS rotary vacuum filter, 4' x 5'
1—Oliver horizontal filter, 3'
1—GATX SS pilot plant filter, 2' x 6"
1—Oliver SS rotary vacuum pressure precoat filter, 5'3" x 8'
10—Shriver plate and frame filter presses, 12" x 42"
1—Shriver aluminum 30" x 30" P&F filter press, 30 chambers

CENTRIFUGES

1—Fletcher 48" SS under-driven centrifuge, complete with perforate basket and motor
1—AT&M 48" SS suspended type centrifuge, complete with plow, motor and imperforate basket
7—Western States 40" type 316 SS suspended type centrifuges complete with perforated baskets, plows and 40 HP motors. Year built 1953
2—Fletcher 40" under driven rubber covered centrifuges with perforate baskets and motors

THE GELB GIRL—OCTOBER 1960

1—Tolhurst 26" SS under-driven centrifuge complete with perforate basket and motor
2—AT&M type 316 SS suspended type centrifuges, complete with 26" perforate baskets, plows and motors
1—Sharples type 316 SS Super-D-Canter, Model PN-14
4—Tolhurst 40" center slung rubber covered centrifuges, with perforate baskets and motors

MIXERS

1—Cleveland SS double cone blender, 85 cu. ft. complete with drive and motor
2—Sturtevant #7 dustite rotary batch blenders, NEW
1—Richmond Engineering type 316 SS 40 cu. ft. horizontal double ribbon blender
15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
1—Baker Perkins Size 20, 2000 gal. double arm jacketed vacuum mixer with double naben blades
1—Baker Perkins Size 16, Type UUEM, 150 gal. jacketed double arm dispersion type mixer, complete with compression cover and 100 HP motor
2—Baker Perkins 20 gal. SS jacketed vacuum double arm mixers
1—Stokes SS granulating mixer, Model 21 J

MISCELLANEOUS

1—Vulcan SS bubble cap column, 4' x 25 plates
1—Badger type 316 SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
4—Davis Engineering Carpenter 20 heat exchangers, 125 sq. ft., NEW
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
1—Condenser Service type 316 SS heat exchanger, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 and 600 sq. ft.
1—Downington type 316 SS heat exchanger, 750 sq. ft.
2—Swenson type 316 SS vacuum crystallizer, 3'6"x12', 2'x12'
3—Williams type 316 SS hammermills, Model AK
1—Sprout Waldron Model 501-D pelleter
1—Ross 6" x 14", 3 roll paint mill, complete
1—Stokes #412F vacuum pump, complete

1—Banbury #1 mixer, chrome plated rotors, with 50 HP motor.
1—Robinson SS 125 cu. ft. horiz. double ribbon blender
1—Griscom Russell Stainless steel heat exchanger, 900 sq. ft.
1—Oliver SS rotary vacuum precoat filter, 3' x 2'

R. GELB & SONS, INC.

U. S. HIGHWAY 22, UNION, N. J. · MURDOCK 6-4900

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ELECTR-O-PROBE®

A CAPACITANCE-ACTUATED SUPER-SENSITIVE ELECTRONIC RELAY

1. Will indicate high or low liquid or solid level
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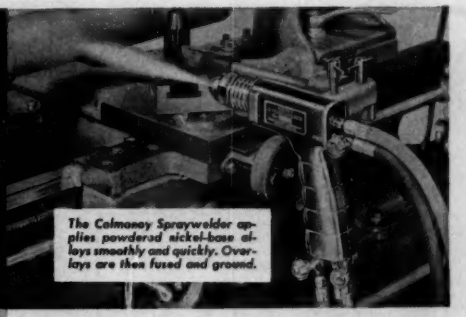

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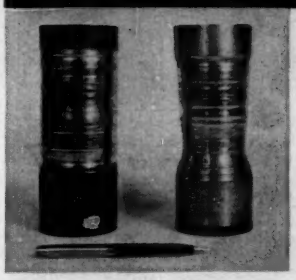

Left: mild steel sleeve with Colmonoy No. 6 overlay after 395 days service. Right: stainless steel (316) sleeve after only 105 days service.

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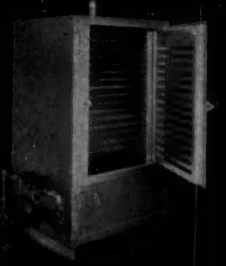

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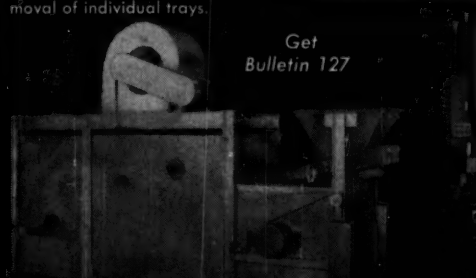

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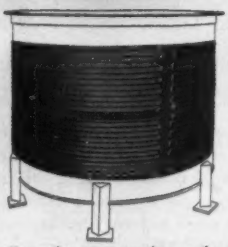

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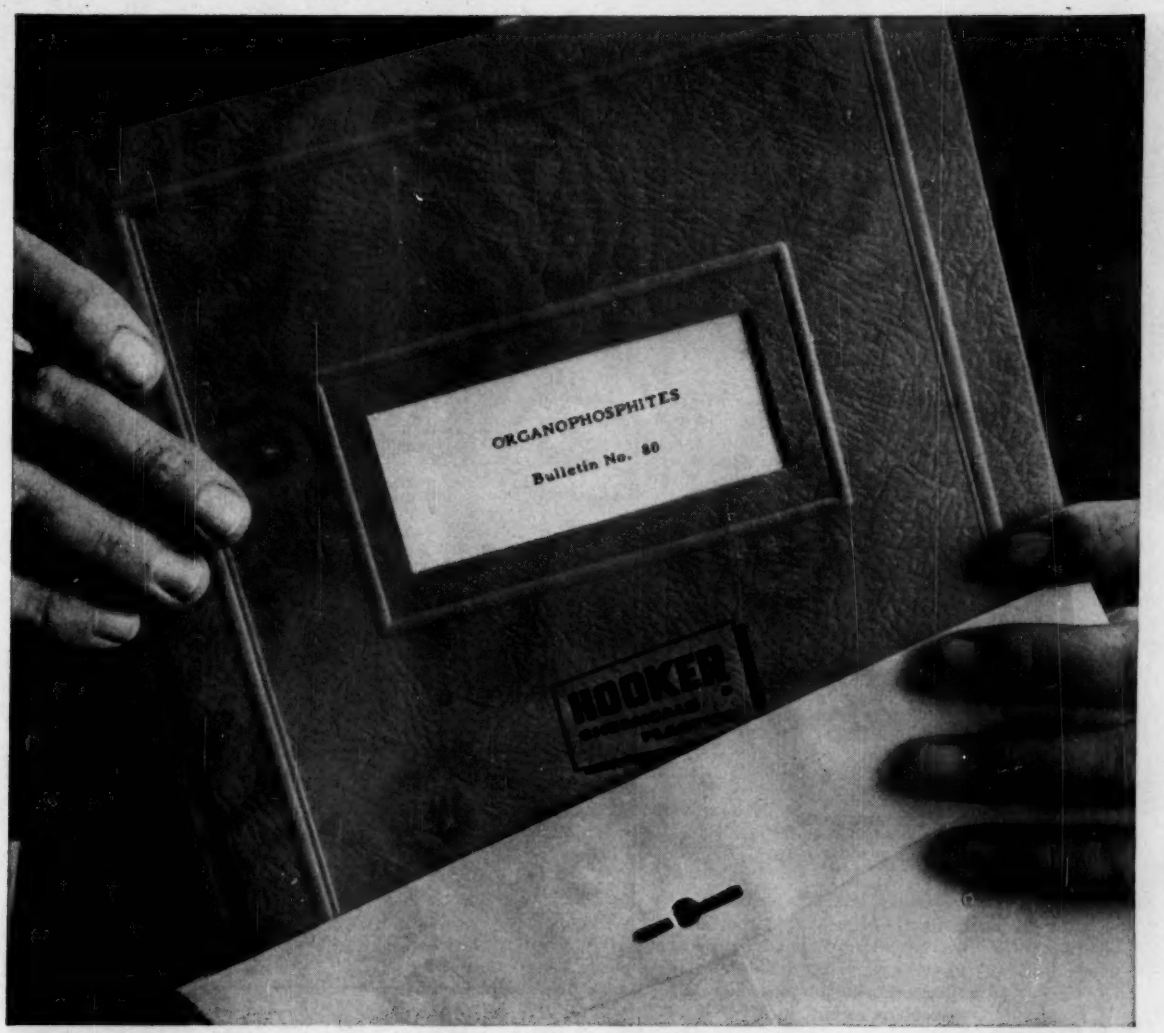

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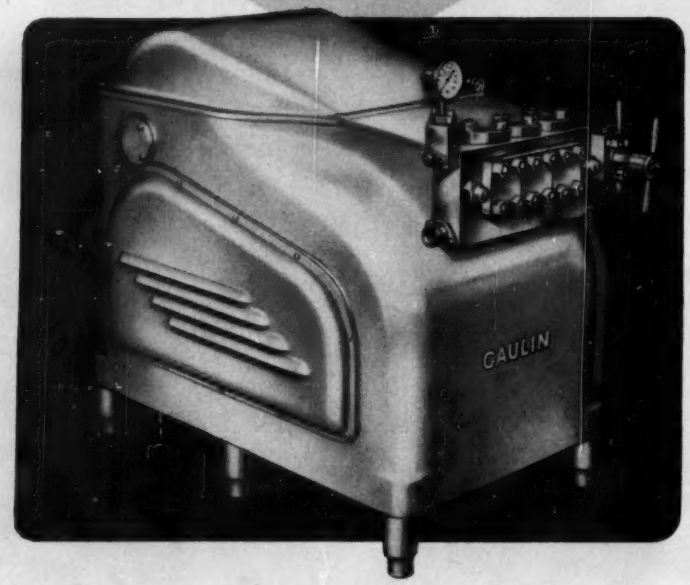

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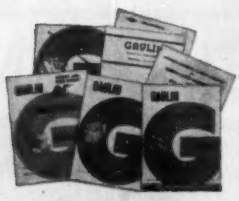

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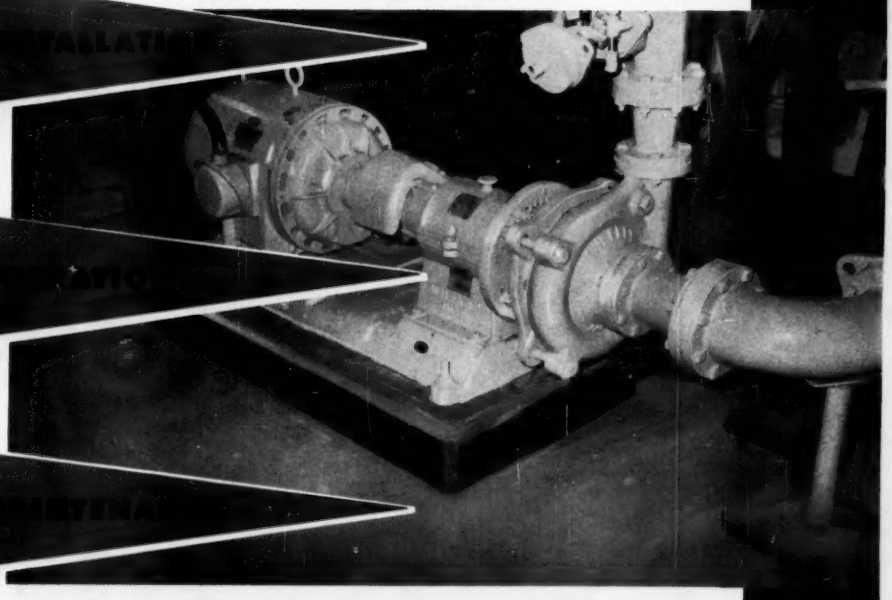

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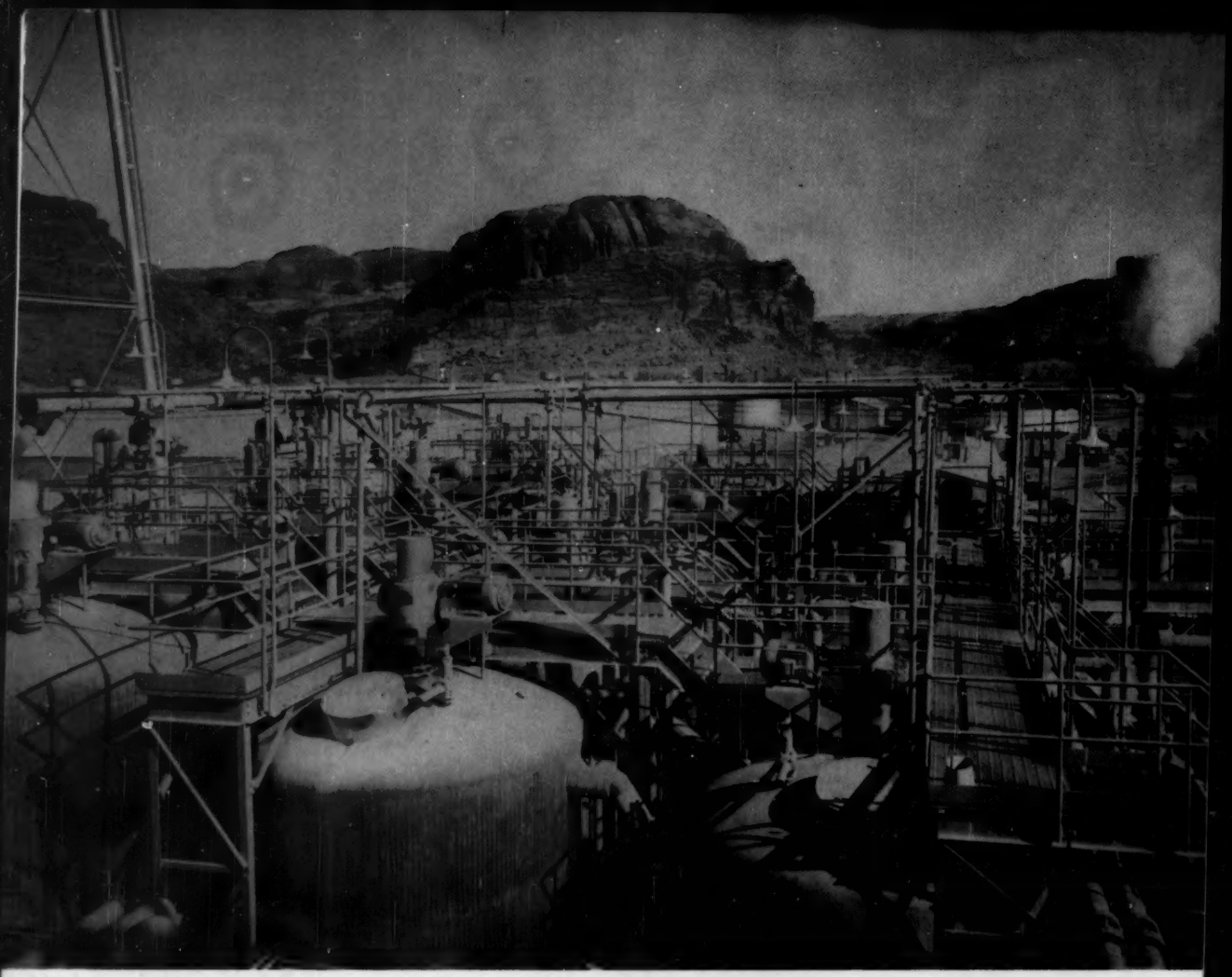

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